

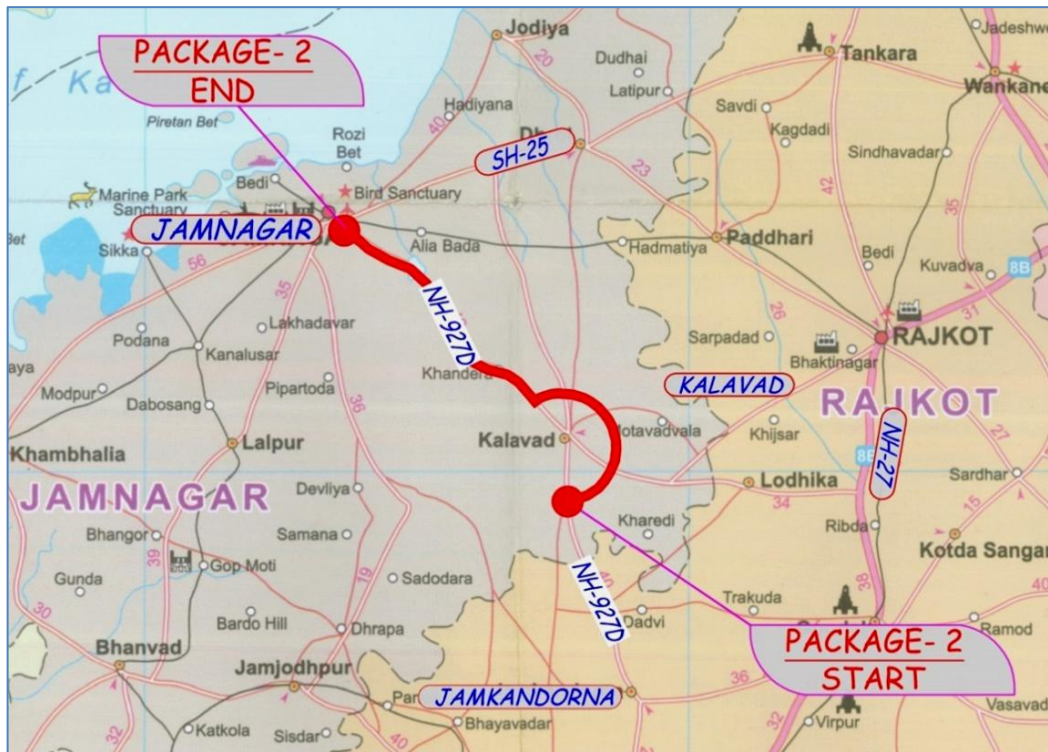


ROADS AND BUILDINGS DEPARTMENT Government of Gujarat

Consultancy Services for Project Management Phase-I including Preparation of Detailed Project Report for up gradation of Junction with NH-8B near **Kalavad-Jamnagar Section (Package-2)** of NH-927D from Ex. Km. 50+925 of SH-26 (Old) to Ex. Km. 3+720 of SH-26 in the State of Gujarat to four lane with paved shoulder configuration (Package No-NH/IAHE/18)

REVISED FINAL DETAILED PROJECT REPORT

VOLUME-I: MAIN REPORT



JULY – 2025

Submitted By



CONSULTING ENGINEERS GROUP LTD.
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EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

ES.1 PROJECT BACKGROUND

The Indian Academy of Highway Engineers (IAHE) has been entrusted with the assignment of Project Management Consultancy Phase I including preparation of Detailed Project Report of selected stretches/corridors of National Highways for Four laning with paved shoulder configuration in the States of Maharashtra, Gujarat, Chhattisgarh, Rajasthan and Karnataka. Under this phase, Government of India felt the necessity of partially access controlled corridor between Dhoraji and Jamnagar through upgradation of a 105 km long section of NH-927D. The present SH-26 notified into NH-927D vide S.O. No. 1522(E) enclosed as **Annexure 1.1.**

The proposed improvements of Dhoraji-Jamnagar highway aims for:

- Important Interstate connectivity between Dhoraji to Jamnagar Port Centre.
- Connectivity to many headquarters/taluka place developed as business centre and Agriculture Marketing Yard.
- Better connectivity to important town Kalavad and Jamkandorna along the project corridor.
- Provide a platform for better economic and Industrial growth of the region.

IAHE has invited proposal for carrying out Feasibility Study and Detailed project preparation for upgrading to 4 lane with paved shoulders configuration of Dhoraji-Jamnagar section of NH-927D in the state of Gujarat (Package No: NH/IAHE/18).

The work for Consultancy Services for Preparation of Feasibility cum Detailed Design Report of Dhoraji-Jamnagar Section of NH-927D has been awarded to M/s Consulting Engineers Group Ltd., Jaipur vide IAHE/Admin/07/Project-MORT&H/2014-15/18 dated 14.05.2015. Accordingly, consultant has commenced the services on 29.05.2015 vide CEG/D-121/2015/79 dated 22.05.2015. After detail reconnaissance survey and preliminary option study Draft Inception Report has been submitted by consultant on 19.06.2015 vide CEG/D-121/2015/128. The comments on Draft Inception Report were issued vide IAHE/DPR/Tech/NH-IAHE-18/2015-16 dated 20.07.2015. The consultant after incorporating the comments on Draft Inception Report, Final Inception Report has been submitted vide CEG/D-121/2015/211 dated 29.07.2015. Accordingly, after completion of all Survey and Investigations, Draft Feasibility Report for the complete project has been submitted vide CEG/D-121/2015/308 dated 08.10.2015. The various presentations on Draft Feasibility Report and for finalization of alignment have been executed.

1. Presentation on 03.11.2015 with IAHE at Noida and It was decided by IAHE officials to finalize alignment with State PWD and Regional Office MoRTH and IAHE issued

- letter to CE-NH-PWD Gujarat to furnish the comments on Draft Feasibility Report vide IAHE/DPR/Tech/NH-IAHE-18/2015-16.
2. On 30.11.2015, a presentation was conducted on 30.11.2015 at CE-NH, R&B Dept. Secretariat, Gandhinagar.
 3. Further a meeting at Sachivalaya, Gandhi Nagar, Gujarat has been proposed on 06.02.2016 to finalize the alignment and comments on Draft Feasibility Report.
 4. A meeting and presentation on 24.02.2016 have been conducted at IAHE Noida and comments has been issued on 04.03.2016 and asked to take comments from state PWD and alignments finalization with project packaging Packages after due consultation with state PWD.
 5. The compliance of comments issued for meeting on 24.02.2016 dated 04.03.2016 has been made by consultant vide letter CEG/D-121/2015/606.
 6. Further State PWD/RO-MoRTH held presentation meeting at Secretariat Gandhi Nagar on 02.03.2016 and concluded that 2 lane paved shoulder configuration should be adopted for entire stretch and bypass are to be avoided.
 7. Further MoRTH New Delhi call a meeting on 28.04.2016 at CE(P4) MoRTH, Transport Bhawan, New Delhi to finalize the alignment and Project configuration for Two lane and Four lane.
 8. The MoRTH, New Delhi was issued Minutes of Meeting dated 28.04.2016 dated 09.05.2016 vide RW/NH/1203/07/2045/PS-4/GJ dated 09.05.2016 and directed for required statutory clearance and divide the project into packages for speedy Implementation. Based on traffic scenario, it is proposed to take the project in two lane paved shoulder configurations for whole stretch.
 9. On 10.05.2016, IAHE vide his letter IAHE/DPR/Tech/Misc/01/2015-16 dated 10.05.2016 issued to NHAI for stretches coming under Four Lanning and asked to expedite the comments on Draft Feasibility by RO MoRTH and State B & R Deptt.
 10. Further MoRTH vide RW/NH-12037/02/201/PS-4/GJ dated 03.06.2016 issued latest guide line RW/NH-33044/37/2015/S&RR dated 26.05.2016 for development of project stretches for 2 lane and 4 lane and It is directed to take up the stretches for four lane having Traffic trigger 10000 PCU.
 11. The consultant has submitted the eligible four laning stretches as per New MoRTH guide line for which one section of this project NH-927D from Jamnagar to Kalavad (Ext. Km 3+720 to Ext. Km 50+925) shall be eligible for four lanes. The Proposal for the same was submitted by consultant vide CEG/D-121/2015/133 dated 13.06.2016.

The Final Feasibility report of package-2 has been submitted vide CEG/D-121/2015/493 Dated 19.12.2016. Accordingly, the DPR consultant incorporated the observations received

from IAHE on Draft Feasibility Report and it has been decided to divide project highway in two packages by considering the Traffic demand and pattern. The Package-1 is for Dhoraji-Jamkandorna-Kalavad section for two lane paved shoulder and Package-2 for Kalavad-Jamnagar section for four laning upgradation.

Further Draft DPR for Package-2 has been submitted on 09.08.2017.

Final DPR for Package-2 has been submitted on 06.07.2018.

Submission of Revised DPR proposal has been done on 18.02.2025 keeping Kalavad bypass as 4-lane.

This report Represents Final Detailed Project Report for Package-2 i.e. Kalavad-Jamnagar Section (ROW of 30-45m) with 4 lane Kalavad bypass (ROW of 45m).

ES.2 PROJECT DESCRIPTION

National Highway No. 927D (NH 927D) lies in western India. Earlier it was SH-26 and recently converted into NH-927D. The SH-26 notified into NH-927D vide S.O. No. 1522(E). The project road starts from km 50+925 of SH-26 (old). The project end point is at km 3+720 junction of SH-26 (old) and SH-25. The existing length as per km stone difference is 47.205 km. The existing project highway is mainly having intermediate lane configuration except in Kalavad town with 4-lane configuration road.

The following reports and documents are to be submitted as per the Terms of Reference:

- ❖ Stage I
 - Quality Assurance Plan (QAP) Document (Already submitted)
 - Inception Report (IR) (Already submitted)
- ❖ Stage II
 - Feasibility Report
 - Strip Plans and Clearances
 - Land Acquisition Report
- ❖ Stage III
 - Draft Detailed Project Report (DPR)
 - Final Detailed Project Report

ES.3 SOCIO-ECONOMIC PROFILE OF THE PROJECT INFLUENCE AREA

The project influence areas of the proposed project lie in Jamnagar district, in the state of Gujarat. The project stretch starts from Kalavad of SH-23 Junction and ends at Jamnagar of SH-25 Junction. The project stretch having 47.572 km length in Jamnagar district. It is expected that about 2,160,119 persons are likely to be benefited in Jamnagar from the project

area. The project area is having 152 people per sq.km, sex ratio 939, literacy rate 73.65%, 8.73% schedule caste population and 0.55% of schedule tribe population.

ES.4 TRAFFIC STUDIES AND ANALYSIS

To capture traffic flow characteristics and travel pattern of users passing through the project road and other characteristics related to miscellaneous requirements as per the TOR revised Traffic survey has been conducted in Month of December 2024. The CVC-1, OD Survey & Axle Load has been conducted at Km 9+430 & CVC-2 at Km 52+200.

ES.4.1 Classified Traffic Volume Counts

The Annual Average Daily Traffic (AADT) in terms of Vehicles and PCU for both directions traffic is shown in **Table ES.1** given below:

Table ES.1: Annual Average Daily Traffic (AADT) at km 9+430

Categories	Km 9+430 AADT (Both Direction)	
	Vehicles	PCU
2-Wheeler	5,015	2,508
3-Wheeler	571	571
Passenger Car	3,182	3,182
Mini LCV	526	526
Mini Bus	8	12
Standard Bus	190	286
LCV - 4 Tyre	0	0
LCV - 6 Tyre	343	515
2-Axle	417	1,251
3-Axle	148	444
MAV (4 to 6)	193	869
OSV (7++ Axle)	0	0
HCM/EME	7	32
Tractors-With Trailer	95	428
Tractors-Without Trailer	17	26
Bi-Cycle	5	3
Cycle-Rickshaw	0	0
Animal-Drawn	0	0

Categories	Km 9+430 AADT (Both Direction)	
	Vehicles	PCU
Hand-Drawn	0	0
Exempted Vehicle	113	113
Total Commercial Traffic	1,306	3,409
Total Tollable Traffic	5,014	7,117
Total Traffic	10,830	10,766

It is observed that the total traffic at km 9+430 is found to be 10,830 vehicles and the total PCU for the same road segment is 10,766. From the survey data it is understood that at this location 80% to 85% traffic composes of 2 Wheelers, 3 Wheelers & Cars, while 15% to 20% is commercial traffic.

Table ES.2: Annual Average Daily Traffic (AADT) at km 52+200

Categories	Km 52+200 AADT (Both Direction)	
	Vehicles	PCU
2-Wheeler	2,052	1,026
3-Wheeler	305	305
Passenger Car	2,082	2,082
Mini LCV	273	273
Mini Bus	11	17
Standard Bus	130	196
LCV - 4 Tyre	0	0
LCV - 6 Tyre	86	129
2-Axle	185	555
3-Axle	90	270
MAV (4 to 6)	104	468
OSV (7++ Axle)	0	0
HCM/EME	1	5
Tractors-With Trailer	68	306
Tractors-Without Trailer	2	4

Categories	Km 52+200 AADT (Both Direction)	
	Vehicles	PCU
Bi-Cycle	4	2
Cycle-Rickshaw	0	0
Animal-Drawn	0	0
Hand-Drawn	0	0
Exempted Vehicle	2	2
Total Commercial Traffic	607	1,640
Total Tollable Traffic	2,962	3,995
Total Traffic	5,395	5,640

It is observed that the total traffic at km 52+200, CVC-2 road segment from Dhoraji to Kalavad is 5,395 vehicles and the total PCU for the same segment is 5,640. From the survey data it is understood that at this location 80% to 90% traffic composes of 2 Wheelers, 3 Wheelers & Cars, while 10% to 20% is commercial traffic.

ES.4.2 Turning Movement Survey

The turning movement survey was conducted at four major intersections on the project highway to obtain information on directional movement of traffic at intersections along the highway. The 24-hour count data for each location has been analyzed for the total & peak hour traffic volume and cross road traffic.

Table ES.3: Cross Road Traffic at all the Major Intersections (in PCU)

S. No.	Location	Type of Junction	Cross Road	Cross Road Traffic (in PCU's)		
				Slow	Fast	Total
1	Km 4+700	4 Arm Junction SH-25	Along Jamnagar	69	11638	11707
			Along Rajkot Road	92	18399	18491
			Along Dwarka Road	30	23275	23305
2	Km 11+300	3 Arm Junction	Along Aliyapada Road	45	1469	1514
3	Km 45+900	3 Arm Junction SH-94	Along Falla Road	112	2906	3018
4	Km 46+500	3 Arm Junction SH-23	Along Rajkot Road	269	9261	9530

ES.4.3 Axle Load Survey

The primary objective of axle load survey is to determine the Vehicle Damaging Factor (VDF) of commercial vehicles and over loading. The survey was conducted near Thavariya Village at km 9+430 for 1 day on random sampling basis to cover directional traffic for both empty and loaded commercial vehicles using portable weighing pads. The summarized VDF values are presented in **Table ES.4** given below.

Table ES.4: Recommended VDF

Vehicles	VDF	Remarks
LCV	0.31	Values adopted as per the findings.
Bus	0.80	At this location, the value is revised based on the past experience.
2T	7.62	Values adopted as per the findings.
3T	7.56	Values adopted as per the findings.
MAV	14.09	Values adopted as per the findings.

ES.4.4 Speed and Delay Surveys

The survey was conducted by adopting moving car observer method. The range of speed found along the project corridor is 45 km/hr to 55 km/hr.

ES.4.5 Traffic Forecast

Traffic forecasting is at best an approximation, which is based on analysis of available data. Traffic is generated as a result of the interplay of a number of contributory factors, some of which are difficult to estimate with their trend in economy. Forecasts of traffic have, therefore, to be dependent on the forecasts factors such as Vehicle Ownership, Net National Product (NNP), Net State Domestic Product (NSDP), & Per Capita Income (PCI). Future pattern of change in these factors can be estimated with only a limited degree of accuracy and hence the forecasting of future traffic levels cannot be precise.

In absence of such data, IRC 37 2018 recommends the growth rate of 5% and same has been used for calculating projected traffic. Traffic projections were made by applying the growth rates to the base year (2024) traffic. Projections are undertaken up to time horizon year 2044-45 (20 years).

Table ES.5: Projected Normal Traffic in AADT (PCU) for CVC-1 at km 9+430

S. No.	Year	Total AADT (PCU)
		At km 9+340
1	2024	10,766
2	2025	11,304
3	2026	11,870

S. No.	Year	Total AADT (PCU)
		At km 9+340
4	2027	12,463
5	2028	13,086
6	2029	13,740
7	2030	14,427
8	2031	15,149
9	2032	15,906
10	2033	16,702
11	2034	17,537
12	2035	18,414
13	2036	19,334
14	2037	20,301
15	2038	21,316
16	2039	22,382
17	2040	23,501
18	2041	24,676
19	2042	25,910
20	2043	27,205
21	2044	28,565
22	2045	29,994

Table ES.6: Projected Normal Traffic in AADT (PCU) for CVC-2 at km 52+200

S. No.	Year	Total AADT (PCU)
		At km 52+200
1	2024	5,640
2	2025	5,922
3	2026	6,218
4	2027	6,529
5	2028	6,855
6	2029	7,198
7	2030	7,558
8	2031	7,936
9	2032	8,333
10	2033	8,749
11	2034	9,187
12	2035	9,646

S. No.	Year	Total AADT (PCU)
		At km 52+200
13	2036	10,129
14	2037	10,635
15	2038	11,167
16	2039	11,725
17	2040	12,311
18	2041	12,927
19	2042	13,573
20	2043	14,252
21	2044	14,965
22	2045	15,713

ES.5 ENGINEERING SURVEYS AND INVESTIGATIONS

The consultants have carried out engineering surveys and investigations that include Topographic Surveys, Road Inventory and Pavement Condition Surveys, Alignment Studies, Pavement Surface Roughness Survey, Environmental Screening and Assessment, Social Screening Assessment, Pavement Composition Investigations, Preliminary Material Investigations for Construction Materials, Inventory and Condition Surveys for Bridges, Culverts and other Structures.

ES.5.1 Land Use and Terrain

Land use pattern along the project corridor is mainly agricultural land and built-up. Barren land and forest area are in very few stretches along the project road.

ES.5.2 Carriageway Width

The existing carriageway width, in 92 % of the Highway is of Intermediate Lane i.e. 6.10 m and remaining 8% of the highway is of 4-lane carriageway with divider. The stretch wise carriageway width is given in **Table ES.7 below:**

Table ES.7: Existing Road Carriage Width

S. No.	Existing Location		Length (Km)	Carriageway width (m)
	From (Km)	To (Km)		
1	3+720	45+200	41.480	6 m to 6.5 m
2	45+200	48+800	3.600	14 m
3	48+800	50+925	2.125	6 m to 6.5 m

ES.5.3 Existing Junctions

The project corridor involves 4 nos. of existing major junctions & 17 no. minor junctions. The major junctions involve 2 no. with NH & 2 no. with SH.

Table ES.8: Existing Major Junctions

S. No.	Existing Km	Type of Intersection	Cross Road Type	Cross Road Leading to		Remarks
				LHS	RHS	
1	46+500	3-Legged	Existing NH-927D		Rajkot	In Kalavad Village with 4-lane section
2	45+760	3-Legged	SH-94		Phalla	
3	11+210	3-Legged	SH		Aliyapada	
4	4+630	4-Legged	NH-947	Dwarka	Morbi	End Point of Project Road

Table ES.9: Existing Minor Junctions

S. No.	Existing Km	Side	Type of Junction	Type of Surface	Width of Cross Road (m)	Cross Road Leading To
1	47+500	RHS	T	BT	5.4	Mota Bhadukiya
2	47+300	Both	X	CC	4	Pipaliya (LHS) Sardarbag (RHS)
3	45+515	LHS	Y	BT	3.5	Wavadi
4	44+615	LHS	T	BT	3.7	Wavadi
5	38+710	RHS	Y	CC	3.1	Ranuja
6	31+030	RHS	T	BT	6.3	Varudi Temple
7	28+600	LHS	Y	BT	5.6	Khankotda
8	22+235	RHS	Y	BT	4.2	Nani Matli
9	19+850	RHS	T	BT	3.6	Pasaya
10	18+000	RHS	T	BT	4	Beraja
11	17+465	RHS	Y	BT	3.8	Aliya
12	12+200	LHS	Y	BT	3	Miyathara
13	11+980	RHS	T	CC	3.3	Vijrakhi
14	10+345	Both	X	BT	5.3	Suwarada (LHS) (RHS)
15	8+700	RHS	T	CC	5.8	I.O.C. Ltd
16	6+245	Both	X	CC & BT	3.9	Theba (LHS) (RHS)
17	4+630	Both	X	BT	20.5	Khambhaliya (LHS) Dhrol (RHS)

ES.5.4 Existing Pavement Condition

The existing pavement type is flexible having earthen shoulders. Pavement condition is generally good in the project stretch. As per pavement condition survey, 37.20 km length is having good pavement, 0.4 km is fair & 9.660 km is poor.

ES.5.5 Existing Pavement Strength

Benkelman Beam deflection tests of identified stretch 14 km length of the project road were conducted to evaluate the structural strength of the existing pavement. The tests were carried out in accordance with the guidelines of IRC: 81-1997. The characteristic deflection values obtained for the stretches identified are varies between 0.9mm to 2.69mm.

ES.5.6 Pavement Composition

The pavement composition details of the existing pavement were obtained from the examination of test pits excavated at regular intervals along the project road. The details are given in the report on **Material Investigations**. The existing pavement crust thickness varies between 200mm to 685 mm.

ES.5.7 Characteristics of the Existing Subgrade /Borrow Soil

Detailed investigations of the existing subgrade soil & borrow area material were carried out to determine strength and other engineering properties. The results of these investigations are given in **Chapter-8 Pavement Design**. The results depict that, subgrade soil classification comes under group CL & CI (50%), ML & MI (40%) and Other SM & SP (10%). CBR at field density varies between 2% to 13% and CBR at MDD varies between 4% to 23%.

During the field investigations, 13 borrow areas were identified and evaluated in the laboratory. Out of these, the details of borrow areas with CBR ranging from 14% to 18%.

ES.5.8 Existing Cross Drainage Structure

Table ES.10: Existing Major Bridges

S. No.	Location (Km)	River	Span (m)	Super Structure	Sub Structure	Width (m)	Remarks
1	46+270 (47/2)	Dhola Wadi	9 x 7.0	RCC Solid Slab Type	Stone Masonry	8.2	Newly constructed bridge with inadequate vertical clearance (in terms of HFL)
2	35+625 (36/2)	Moti Phuljar	12 x 6.8	RCC Solid Slab Type	Stone Masonry	6.7	Submersible bridge in poor condition

ES.5.8.1 Existing Minor Bridges

There are 16 existing Minor Bridges on the project stretch. The type of superstructure for the Minor Bridges were found to be RCC Solid Slab resting on Stone Masonry Sub-Structure. Some common distresses observed were exposed and corroded reinforcement in slabs; spalling of concrete, damaged/missing railing, growth of vegetation on pier caps &/in vent ways, damaged wearing coat, damaged expansion joints & settlement of embankment around abutments etc. Many bridges were found to be submersible in nature and having Guard Stones instead of Railing & Crash Barrier.

Table ES.11: Existing Minor Bridges

S. No.	Structure No.	Location (Km)	Type of Structure	Span Arrangement (m)	Type of Bridge	Condition
1	46/1	45+730	Minor bridge	1 x 9.10 (Sk)	High Level	Fair
2	45/4	44+990	Minor bridge	2 x 3.00 (Clear)	High Level	Poor
3	45/2	44+570	Minor bridge	2 x 3.00 (Clear)	High Level	Poor
4	41/1	40+365	Minor bridge	2 x 3.00 (Clear)	High Level	Poor
5	40/3	39+990	Minor bridge	2 x 3.00 (Clear) (Sk)	High Level	Poor
6	40/2	39+520	Minor bridge	4 x 1.50 (Clear)	High Level	Poor
7	39/1	38+580	Minor bridge	5 x 6.50	Submersible	Poor
8	38/2	37+955	Minor bridge	2 x 3.00	High Level	Poor
9	37/2	36+880	Minor bridge	5 x 7.00	Submersible*	Fair
10	29/3	28+800	Minor bridge	3 x 6.80	Submersible	Fair
11	29/2	28+600	Minor bridge	5 x 6.80	Submersible	Poor
12	22/2	21+730	Minor bridge	4 x 6.00	Submersible*	Fair
13	21/1	20+275	Minor bridge	2 x 6.00 (Sk)	Submersible	Poor
14	18/3	17+835	Minor bridge	7 x 6.00	Submersible	Poor
15	10/1	9+050	Minor bridge	2 x 5.40	Submersible*	Fair
16	07/2	6+480	Minor bridge	6 x 3.70	Submersible*	Fair

****Never been overtopped but vertical clearance found to be inadequate (freeboard above HFL)***

ES.5.8.2 Existing Culverts/ Causeways

The existing culverts observed along the project road are mainly of three types viz. RCC Slab culverts, Pipe culverts and Causeway. The structural condition of pipe culverts is generally fair, except few partially choked or buried culverts due to heavy vegetation. Most of the slab culverts are in poor condition.

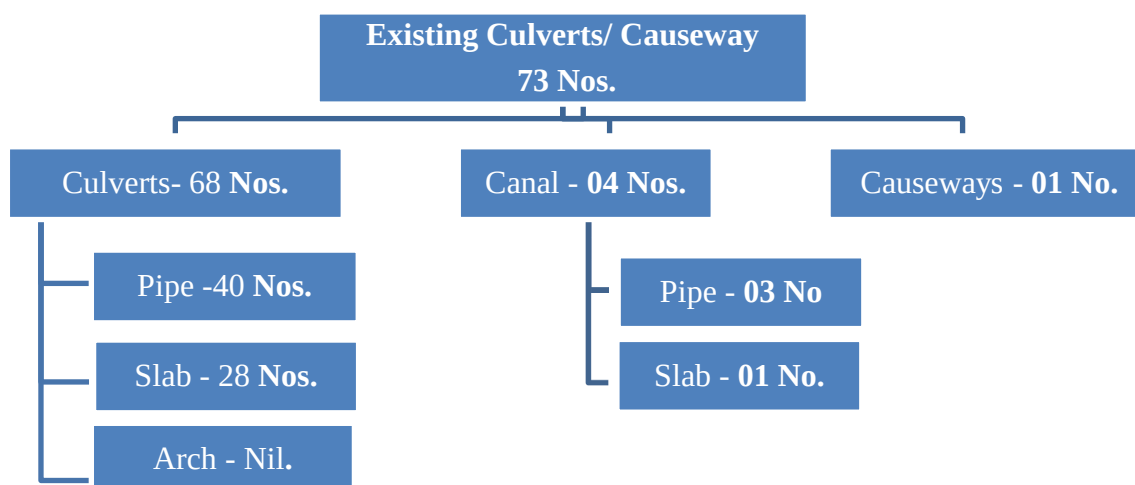


Figure ES.1: Existing Culverts along the Project Road

ES.6 PROPOSED IMPROVEMENTS

Standards mentioned in the Manual of Specifications and standards for four laning of Highways with paved shoulder IRC: SP-84-2019 have been followed except at the locations where some deviation considering minimum land acquisition and R&R issue. The existing highway proposed to be upgraded to four lane with paved shoulder configuration. There are 66 nos. of Deficient geometry stretches with respect to horizontal and vertical geometry. The vertical geometry is also affected due to reconstruction of Bridges and other Cross Drainage works to High-level which are presently submersible. The details of Project proposal for Highway as well as Structures is summarized below with Provision of Project facilities as per specifications.

The major deficiency, as shown in **Table ES.12** below, along the existing project highway is mainly (i) reverse curve with insufficient curve length, (ii) curve radius less than Absolute minimum required i.e. 230m, (iii) curve radius less than Desirable minimum required i.e. 360m, (iv) Broken Back Curves i.e. the curve which are not satisfying the clause 9.1.7 IRC: 73:1 and (v) length of curve is not sufficient as per existing deflection angle which is not satisfying the clause 9.1.5 IRC: 73:1980.

The four locations Kalavad, Vijarkhi, Khandera, Haripar where option study for alignment

alternatives have been explored by providing Bypasses and realignments. The best feasible option has been recommended based on Traffic demand and Techno economical ground. In all above four locations Kalavad is major Taluka town where already four lane roads exist with some Geometric deficiency. It is recommended for bypass as the geometric improvement is not possible due to dense habitation.

The project is generally designed for speed of 100 kmph. The geometry deficiency has been observed at many locations along the project highway. There is total 66 curve deficiencies have been observed, which is summarized below:

Table ES.12: Deficient Curves

S. No.	Number of Locations	Deficiencies
1	3	Reverse curve with insufficient curve length
2	13	Radius less than Absolute minimum required
3	5	Radius less than Desirable minimum required
4	37	Broken Back Curves with sharp reverse curve
5	8	Length of curve and transition is not sufficient as per existing deflection angle

ES.6.1 Widening Scheme and Typical Cross Section

As far as possible the existing center line has been followed for the horizontal alignment design except the proposed realignments and curve improvement locations. Main TCS's proposed are presented below (**Figure ES.2 to ES.17**) for four lane cross section. Summary of widening scheme is as below.

Table ES.13: Details of Widening Scheme

S. No.	TCS Type	Details	Length (m)
1	TCS 1	4 Lane Divided Highway without Service Road with Raised Median for New Construction (Realignment)	5909
2	TCS 1A	4 Lane Divided Highway without Service Road with Raised Median for concentric Widening	342
3	TCS 1B	4 Lane Divided Highway without Service Road with Raised Median for Right side Eccentric Widening (Reconstruction from CTB)	13924
4	TCS 1C	4 Lane Divided Highway without Service Road with Raised Median for Left side Eccentric Widening (Reconstruction from CTB)	5674

S. No.	TCS Type	Details	Length (m)
5	TCS 1D	Reconstruction/Raising Section for 4 Lane Divided Highway without Service Road with Raised Median for Concentric Widening	140
6	TCS 1E	Reconstruction/Raising Section for 4 Lane Divided Highway without Service Road with Raised Median for Right Side Widening	3173
7	TCS 1F	Reconstruction/Raising Section for 4 Lane Divided Highway without Service Road with Raised Median for Left side Widening	606
8	TCS 2	4 Lane Divided Highway with Service Road with Raised Median for Concentric Widening (Overlay & PCC)	1884
9	TCS 3	Typical Cross Section for Flyover with Both Side Service Road with NJB (Span Portion)	70
10	TCS 3A	Typical Cross Section for Flyover with Both Side Service Road with NJB (Approach)	1080
11	TCS 4	Typical Cross Section for VUP with Both Side Slip Road with 7.5m Median (Span Portion)	68
12	TCS 4A	Typical Cross Section for VUP/LVUP with Both Side Slip Road with 5.0m Median (Approach Portion)	3127
13	TCS 5	Typical Cross Section for Bridge and Deck Level- With Footpath 4 Lane Divided Highway	974
14	TCS-6	4 Lane Divided Highway for New Construction in Hilly Section (Both Side Cutting)	2185
15	TCS-7	4 Lane Divided Highway without Service Road with raised Median for New Construction (for Kalavad Bypass)	720
16	TCS-7A	4 Lane Divided Highway with Left Side Service Road with raised Median for New Construction (for Kalavad Bypass)	2950
17	Toll Plaza	Toll Plaza Length	50
18	Toll Plaza Tapering	Tapering on either sides of the toll plaza	310
19	Tapering	Tapering between Two Cross sections	4386
Total			47572

The indicative TCS drawing and schedules are given as below:

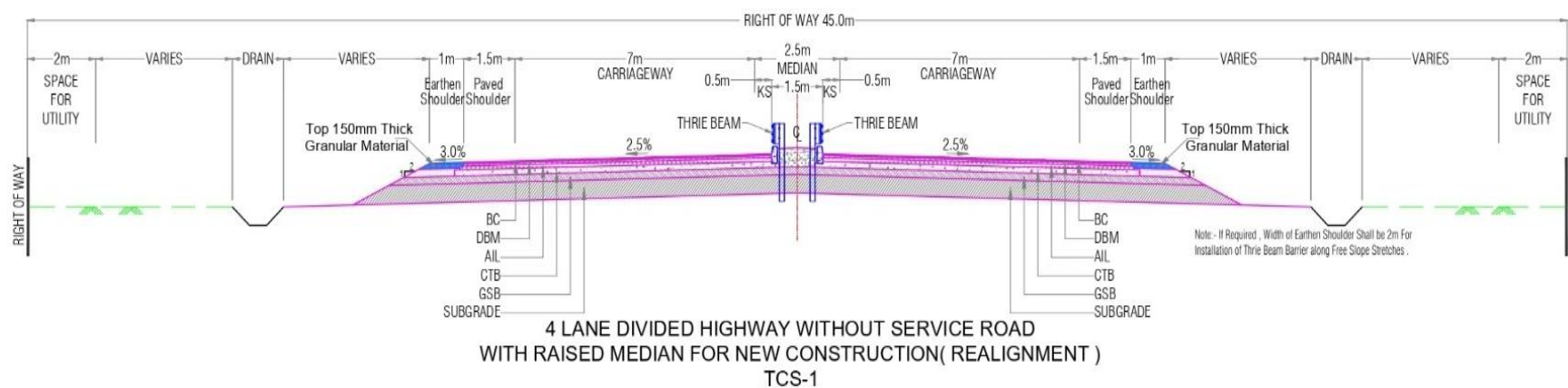


Figure ES.2: TCS-1 for 4 Lane Divided Highway without Service Road with Raised Median for New Construction (Realignment)

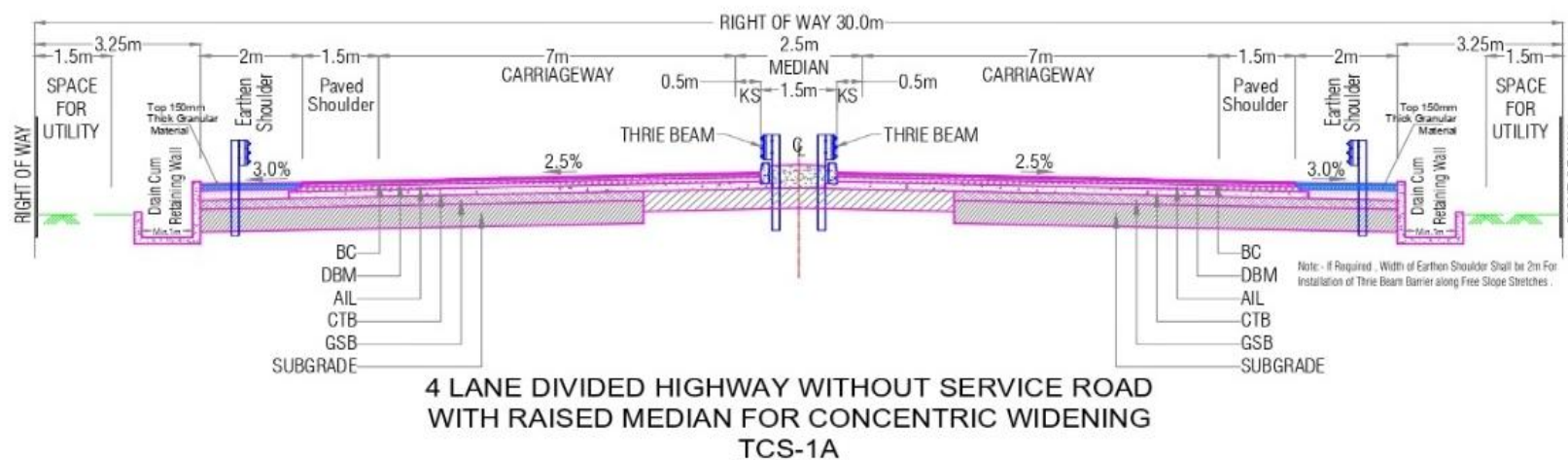
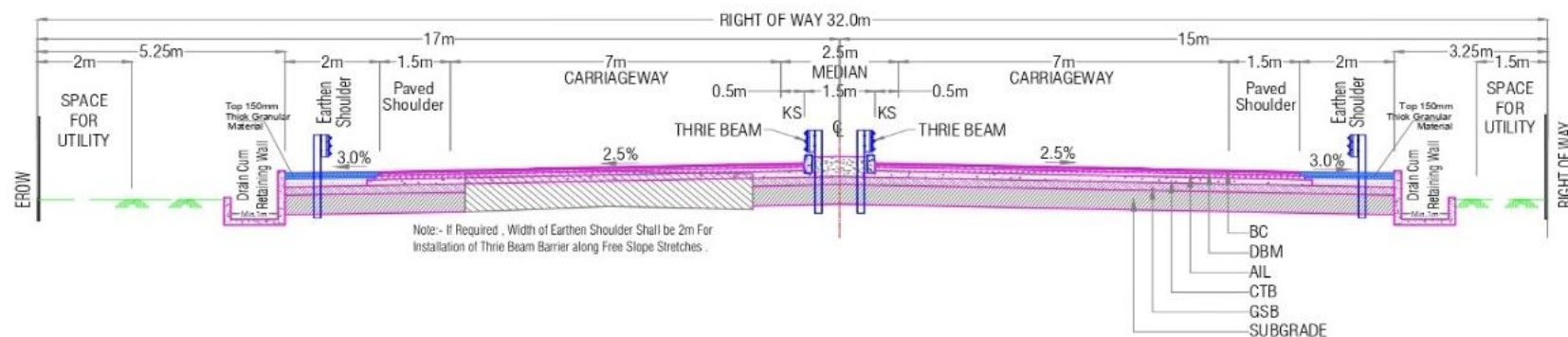
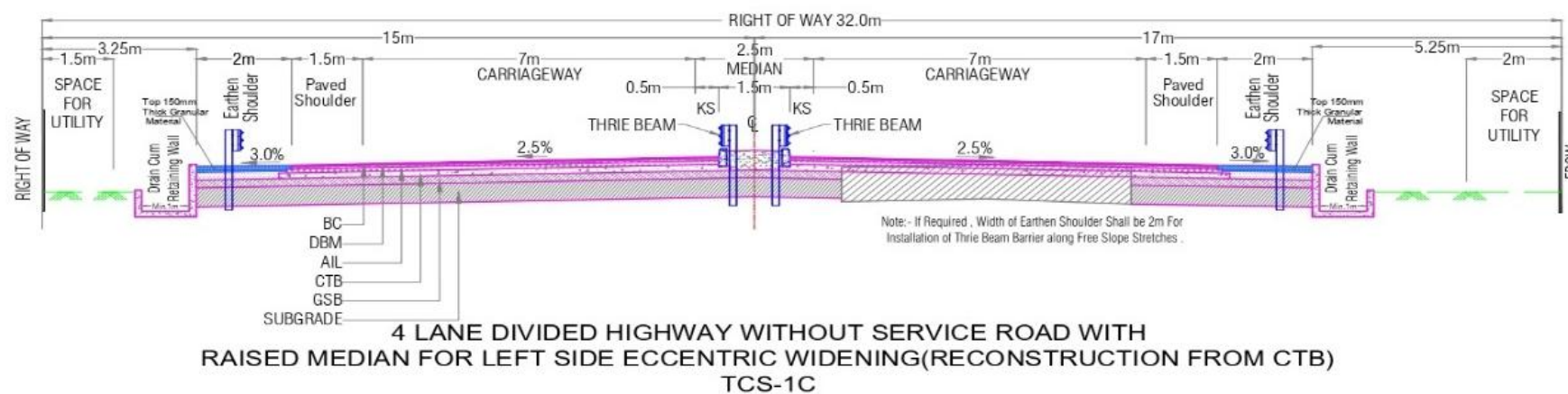


Figure ES.3: TCS-1A for 4 Lane Divided Highway without Service Road with Raised Median for Concentric Widening



**4 LANE DIVIDED HIGHWAY WITHOUT SERVICE ROAD WITH
RAISED MEDIAN FOR RIGHT SIDE ECCENTRIC WIDENING (RECONSTRUCTION FROM CTB)
TCS-1B**

**Figure ES.4: TCS-1B for 4 Lane Divided Highway without Service Road with Raised Median for Right side Eccentric Widening
(Reconstruction from CTB)**



**4 LANE DIVIDED HIGHWAY WITHOUT SERVICE ROAD WITH
RAISED MEDIAN FOR LEFT SIDE ECCENTRIC WIDENING (RECONSTRUCTION FROM CTB)
TCS-1C**

**Figure ES.5: TCS-1C for 4 Lane Divided Highway without Service Road with Raised Median for Left side Eccentric Widening
(Reconstruction from CTB)**

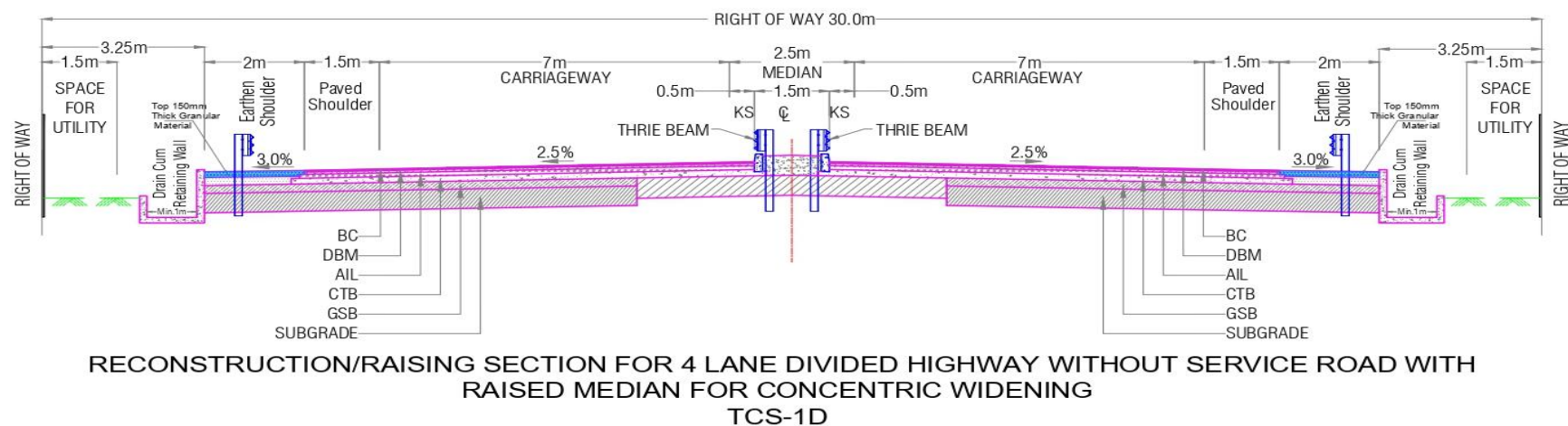


Figure ES.6: TCS-1D for Reconstruction/Raising Section for 4 Lane Divided Highway without Service Road with Raised Median for Concentric Widening

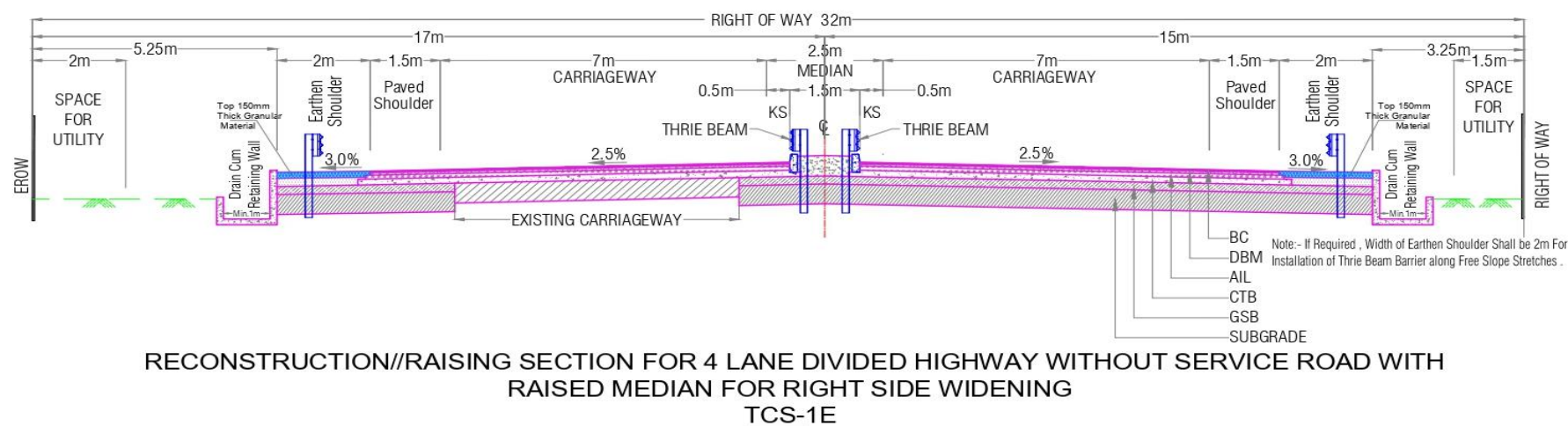


Figure ES.7: TCS-1E for Reconstruction/Raising Section for 4 Lane Divided Highway without Service Road with Raised Median for Right Side Widening

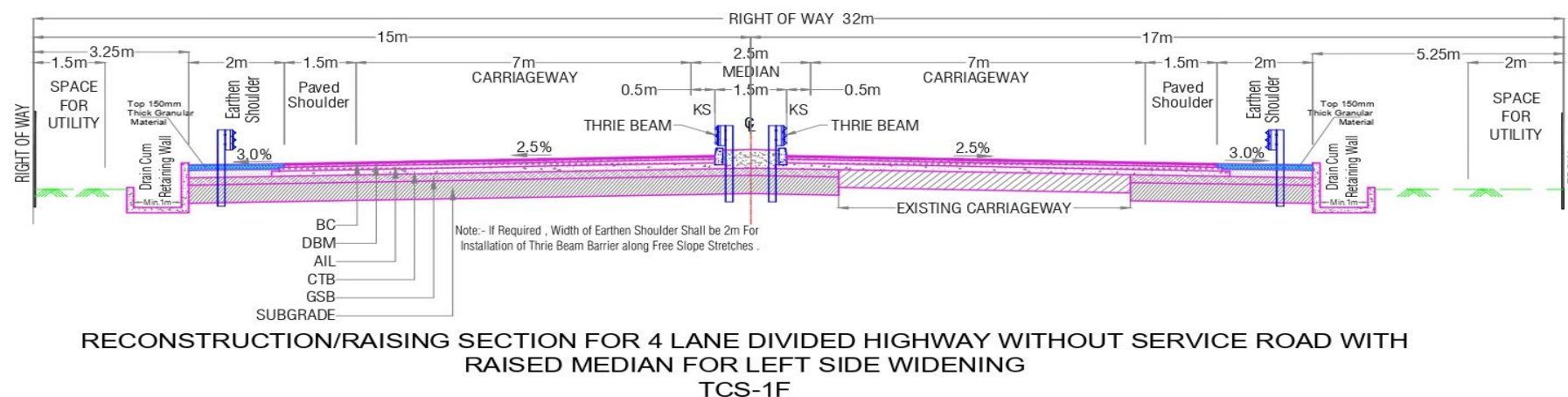


Figure ES.8: TCS-1F for Reconstruction/Raising Section for 4 Lane Divided Highway without Service Road with Raised Median for Left side Widening

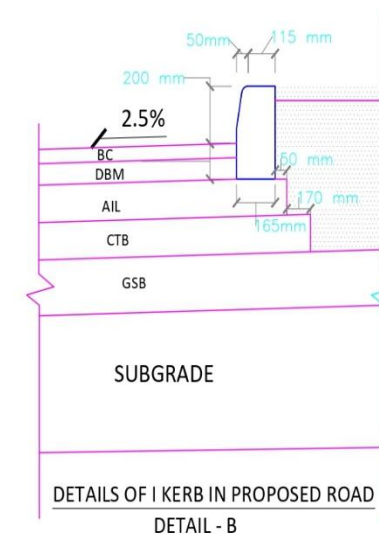
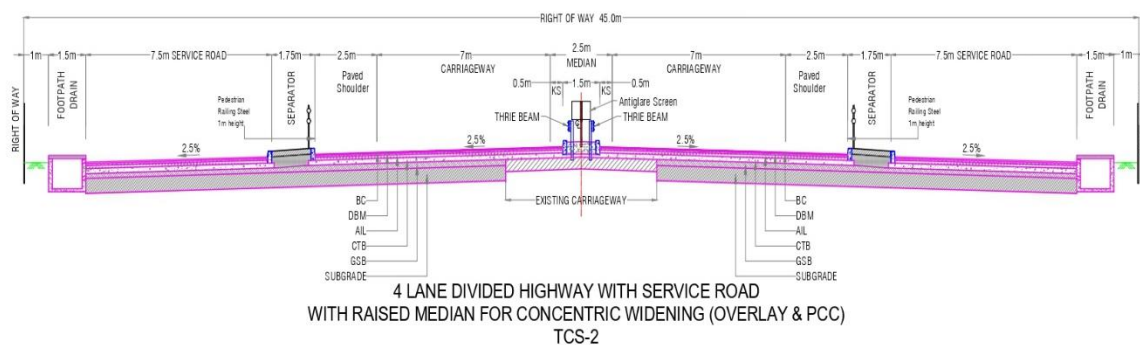


Figure ES.9: TCS-2 for 4 Lane Divided Highway with Service Road with Raised Median for Concentric Widening (Overlay & PCC)

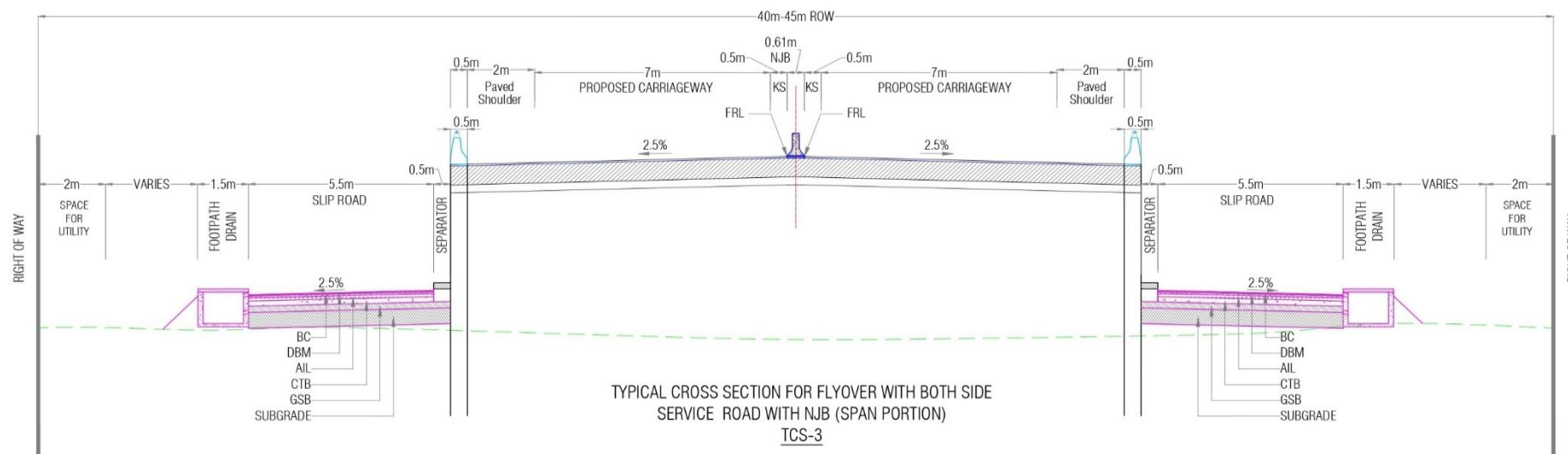


Figure ES.10: TCS-3 Typical Cross Section for Flyover with Both Side Service Road with NJB (Span Portion)

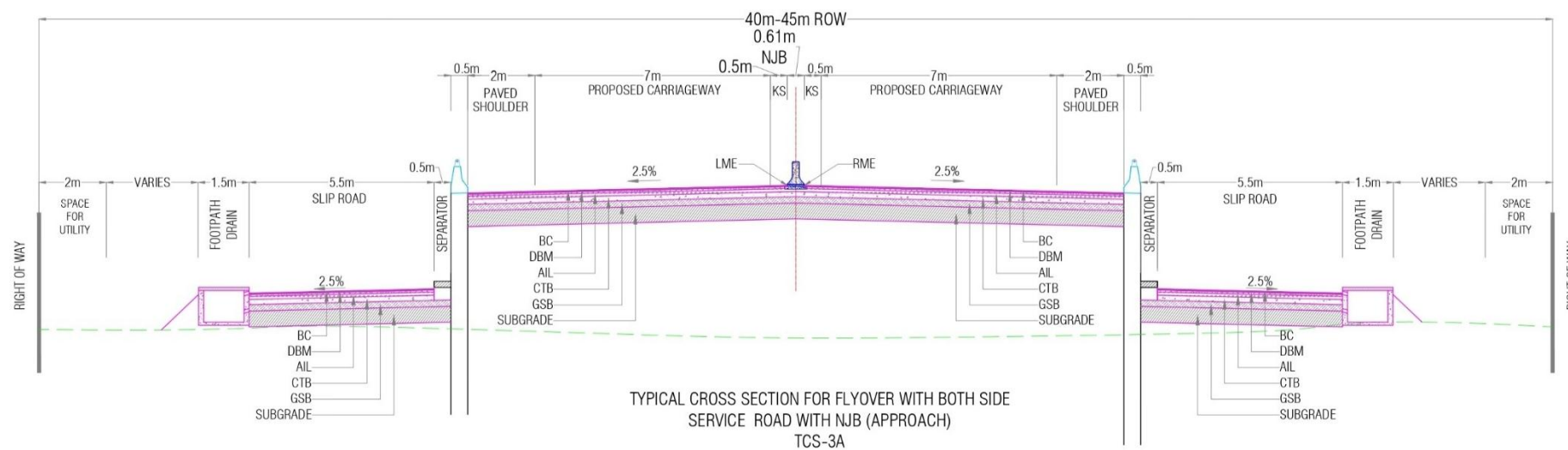


Figure ES.11: TCS-3A Typical Cross Section for Flyover with Both Side Service Road with NJB (Approach)

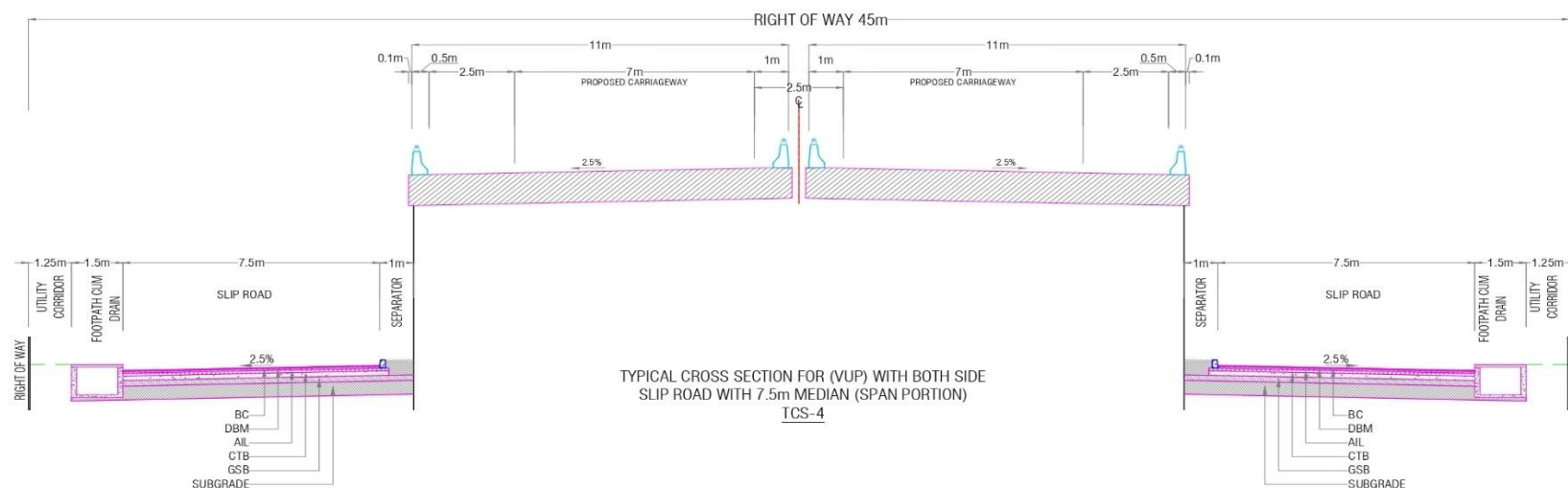


Figure ES.12: TCS-4 Typical Cross Section for VUP with Both Side Slip Road with 7.5m Median (Span Portion)

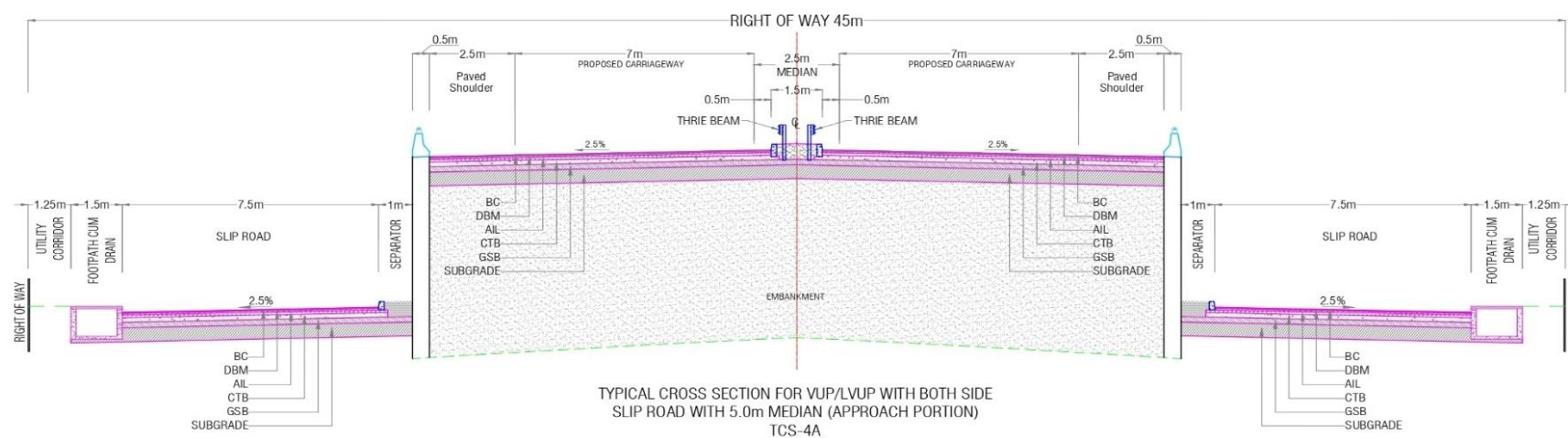


Figure ES.13: TCS-4A Typical Cross Section for VUP/LVUP with Both Side Slip Road with 5.0m Median (Approach Portion)

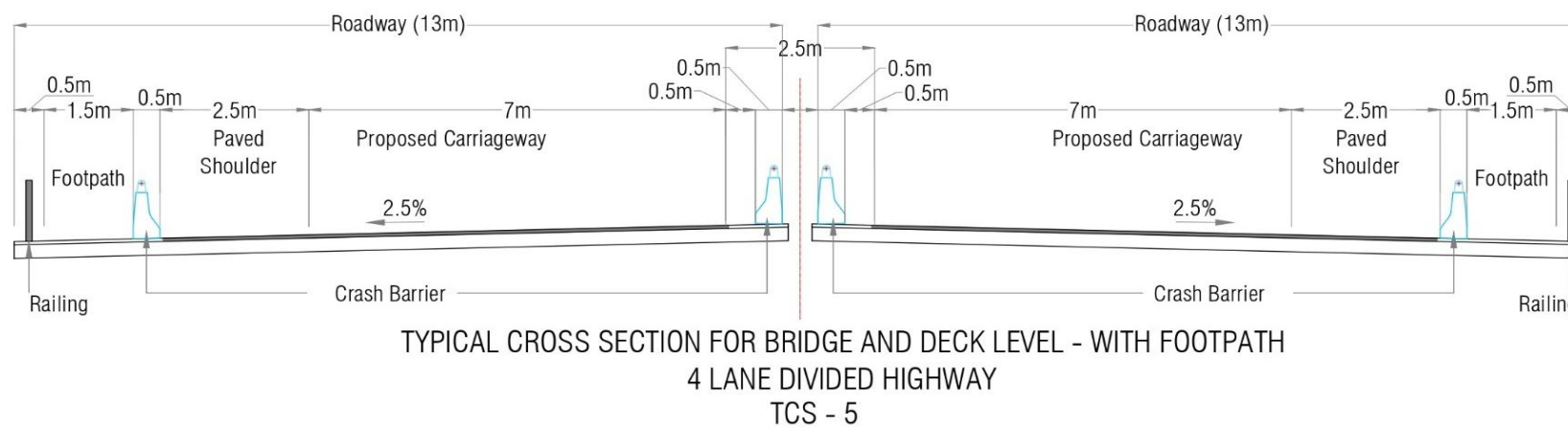


Figure ES.14: TCS-5 Typical Cross Section for Bridge and Deck Level- With Footpath 4 Lane Divided Highway

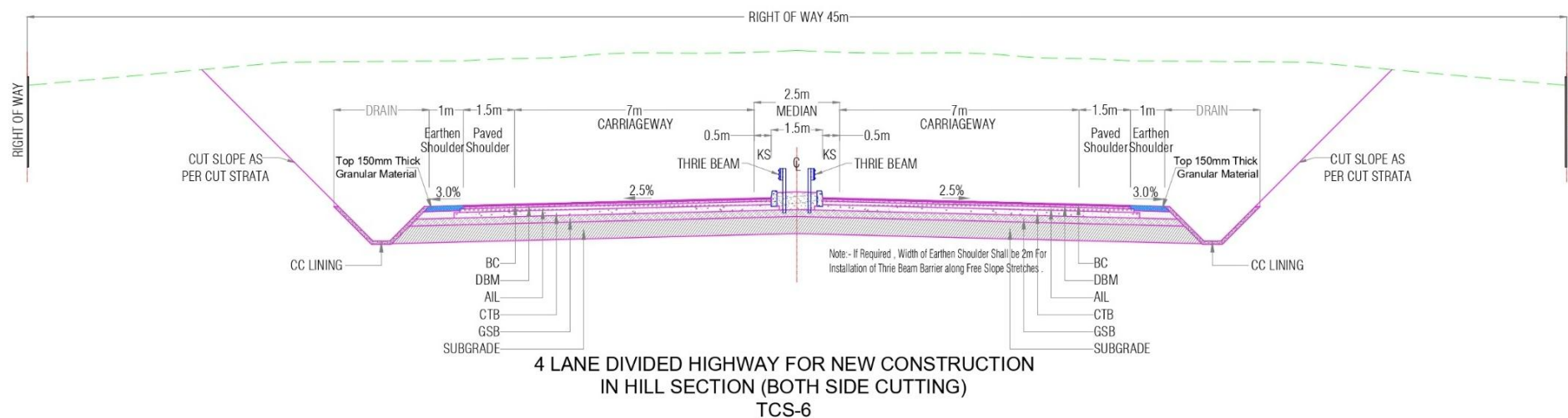


Figure ES.15: TCS-6 4 Lane Divided Highway for New Construction in Hilly Section (Both Side Cutting)

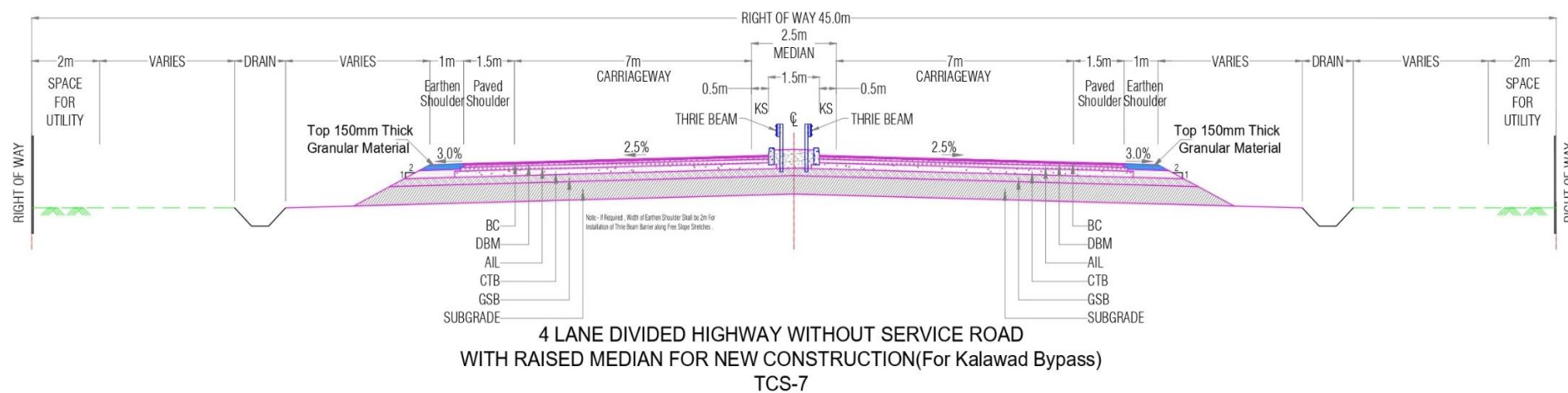


Figure ES.16: TCS-7 for 4 Lane Divided Highway without Service Road with raised Median for New Construction (for Kalavad Bypass)

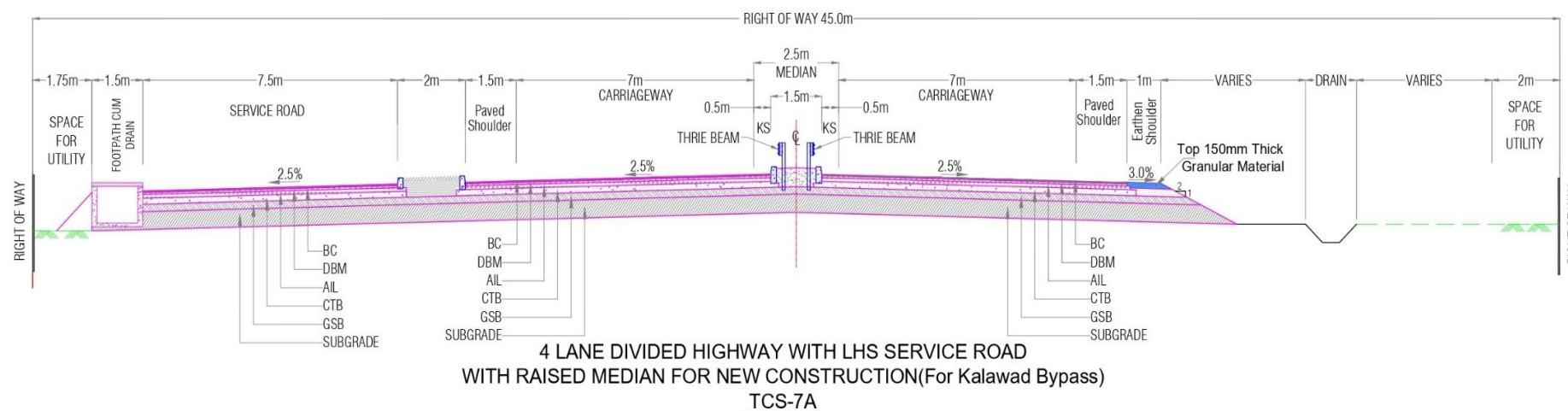


Figure ES.17: TCS-7A for 4 Lane Divided Highway with LHS Service Road with raised Median for New Construction (for Kalavad Bypass)

ES.6.2 Pavement Design

ES.6.2.1 Design Life

For this project, Design period of the flexible pavement is considered as 20 years and for rigid pavement it has been considered as 30 years.

ES.6.2.2 Design Traffic

Design Traffic is adopted 44 MSA for both direction traffic for MCW and 20 MSA for service road.

ES.6.2.3 Design CBR

Keeping in view the availability of soil, the design has been proposed for 8% CBR.

ES.6.2.4 Pavement Design Summary

Since the existing pavement is granular base and sub base, the existing pavement is dismantled and flexible pavement with cement treated base & granular subbase shall be provided on the entire carriageway width and the pavement design for the entire project length is as follows:

Table ES.14: Flexible Pavement Layer Thickness for Main Carriageway

Section	Entire Main Carriageway Including Bypass
Design Traffic, MSA	44
CBR, %	8
Pavement Composition	
Pavement Layers	Thickness (mm)
Bituminous Concrete (BC)	40
Dense Bituminous Macadam (DBM)	60
Aggregate Interlayer (AIL)	100
Cement Treated Base (CTB)	165
Granular Sub-base (GSB)	200
Subgrade	500
Total Pavement Thickness*	565

* Excluding Subgrade

Table ES.15: Flexible Pavement Layer Thickness for Slip / Service Roads

Section	Slip/Service Road
Design Traffic, MSA	20
CBR, %	8

Pavement Composition	
Pavement Layers	Thickness (mm)
Bituminous Concrete (BC)	30
Dense Bituminous Macadam (DBM)	55
Aggregate Interlayer (AIL)	100
Cement Treated Base (CTB)	170
Granular Sub-base (GSB)	200
Subgrade	500
Total Pavement Thickness*	555

* Excluding Subgrade

Table ES.16: Rigid Pavement Layer Thickness for Toll Plaza Section

Section	Toll Plaza Section
CVPD in the year of Completion of Construction	1034
CBR, %	8
Pavement Composition	
Pavement Layers	Thickness (mm)
Pavement Quality Concrete (PQC)	280*
Debonding Layer of Polythene Sheet	Provided as per MoRTH Guideline
Dry Lean Concrete (DLC)	150
Granular Sub – Base (GSB)	150
Subgrade	500
Total Pavement Thickness [#]	580

* Thickness is included of two retexturing and grinding to rectify faulting during service life

[#] Excluding Subgrade

ES.6.3 Inter Sections and Grade Separators

Project highway improvement also involves 5 major junction developments, 20 minor junction development and 4 grade separated Structures.

Table ES.17: List of Proposed Major Junctions

S. No.	Existing Km	Design Chainage	Type of Inter-section	Cross Road Type	Cross Road Leading to		Remarks
					LHS	RHS	
1	Bypass	0.115	3-Legged	Existing NH-927D	Kalavad		Start of Kalavad Bypass
2	Bypass	9.190	3-Legged	Existing NH-927D	Kalavad		End of Kalavad Bypass

S. No.	Existing Km	Design Chainage	Type of Inter-section	Cross Road Type	Cross Road Leading to		Remarks
					LHS	RHS	
3	36+345	16.068	3-Legged	Existing NH-927D	Khandhera		At the Start and End of Khandhera Re-alignment
4	34+500	17.273	3-Legged	Existing NH-927D	Khandhera		
5	11+210	40.104	3-Legged	SH		Aliyapada	-

Table ES.18: List of Proposed Minor Junctions

S. No.	Existing Km	Design Chainage	Side	Type of Junction	Type of Surface	Width of Cross Road (m)	Cross Road Leading To
1	Bypass	2+170	RHS	Y	Earthen Road	7	Balambadh
2	Bypass	2+200	LHS	Y	Earthen Road	11	Kalavad
3	Bypass	4+070	BHS	X	Earthen Road	11 LHS & 8 RHS	Kalavad & Dhedh Khijadiya
4	Bypass	5+885	BHS	X	BT	11	Kalavad & Jivapar
5	41+930	10+390	LHS	Y	Earthen Road	8	Vavdi
6	38+710	13+613	RHS	Y	CC	8	Ranuja
7	33+825	18+495	BHS	X	BT	11	Field & Dhudasiya
8	31+030	20+737	RHS	T	BT	8	Varudi Temple
9	29+500	22+260	RHS	T	BT	8	Dhutarpur
10	28+600	23+047	LHS	Y	BT	7	Khankotda
11	22+235	29+390	RHS	Staggered	BT	7	Nani Matli
12	22+165	29+460	LHS		BT	7	Modpar
13	19+850	31+740	RHS	T	BT	7	Pasaya
14	18+000	33+621	RHS	T	BT	11	Beraja
15	17+465	34+145	RHS	Y	BT	9	Sapda
16	12+200	39+087	LHS	Y	BT	7	Miyathara
17	11+980	39+359	RHS	T	CC	7	Vijrakhi
18	10+345	40+940	Both	X	BT	7	Suwarada (LHS) (RHS)
19	8+700	43+195	RHS	T	CC	11	I.O.C. Ltd.
20	6+245	45+040	Both	X	CC & BT	7	Theba (LHS) (RHS)

Table ES.19: Grade Separated intersection without ramps

S. No.	Existing Km	Design Chainage	Salient Features	Minimum length of viaduct to be provided	Road to be carried over/under the structures
1	Bypass	1.216	VUP	2x10.0x5.5 clear	Mota bhadukiya road
2	Bypass	4.600	VUP	2x12x5.5 clear	SH-23 to Rajkot
3	Bypass	8.255	VUP	2x12x5.5 clear	SH-94
4	4+700	46.670	Flyover	2x30m x 5.5 clear	NH-947 (SH-25)

ES.6.4 Bridge and Culverts

The proposed cross drainage structures for project highway are 5 no. Major Bridge, 14 no. Minor Bridge, 2 no. Minor Bridges on Service Road, 73 no. Culverts along the alignment of the road. Minor Bridges on main carriageway have been proposed for Reconstruction (10 Nos.) / New Construction (04 Nos.). Total 73 nos. culverts including additional culverts that have been proposed in the project stretch. The improvement proposals for existing culverts are proposed for 4 lane configurations.

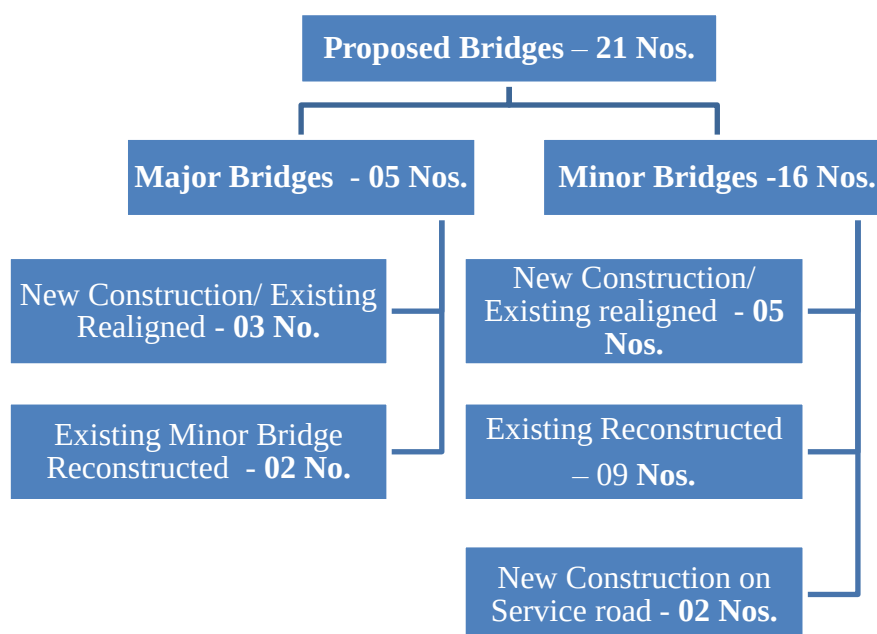


Figure ES.18: Summary of Proposed Bridges

ES.7 PROJECT FACILITIES

To enhance the project facilities, 26 Bus Stops, 2 Truck Lay Bys and 1 Toll Plaza at Ch 41+833 has been proposed.

The existing and proposed Salient Features of the Project Highway are listed in table below:

Table ES.20: Existing and Proposed Salient Features

S. No.	Descriptions	Existing Features	Proposed Features	Remarks
1	ROW	From Km 50+925 to 3+720 = 24.0m	PROW in Brownfield= 30m PROW in Greenfield and Realignment = 45 m PROW at Toll Plaza = 70m. PROW at Bus Bay and Truck Lay Bye = 40m	Approx. 98 Ha. Land acquisition will be required
2	Carriageway Width (m)	Project Road Configuration is Intermediate Lane (6.10 m) to 2-lane except 2.2 km length of 4-lane configuration 3.500 km length in Kalavad.	4-lane configurations from Ch 0.000 to 47.572 (length 47.572 km)	4-lane configuration has been proposed throughout the length.
3	Bridges	Major Bridges – 2 Nos. Minor Bridges – 16 Nos.	Major Bridges – 05 Nos. Minor Bridges – 16 Nos.	Major Bridges: a) New (03 Nos.) b) Existing Minor bridges reconstructed (02 Nos.) Minor Bridges: a) New (05 Nos.) b) Reconstruction (9 Nos.) c) New on Service Road (02 Nos.)
4	Culverts	73 Nos.	77 Nos.	Reconstruction - (58 Nos.) New (19 Nos.)
5	Major Junctions	4 Nos.	5 Nos.	Major Junctions increased due to Bypass.
6	Bypass	Nil	Kalavad- 9430m Length	Total Bypass length is 9.430 km

S. No.	Descriptions	Existing Features	Proposed Features	Remarks
7	Realignments	Nil	1. Haripar-1400m Length 2. Khandera -1373 m Length 3. Vijarkhi- 1970m Length	Total Realignments length is 4.743 km
8	Rest Area	Nil	Nil	Nil
9	Truck Lay Bye	Nil	2 Nos.	Ch 10.517 RHS & Ch 43.982 LHS
10	Bus Stops/Bus Bays	16	26 Nos. (Including Both Side)	Shelter Type Bus stop-12 (Both Side) Bus Bays -14 (Both Side)
11	Drain	Earthen Drain in Few Stretches along the alignment.	Total Length of Drain - RCC Lined Drain- 16.598 Km - Trapezoidal Lined Drain- 4.370 Km - Earthen Drain – 26.020 km - RCC Lined Drain with Retaining wall- 48.156 Km	There is no Existing Line drain along the project stretch
12	Cattle Underpass	Nil	Nil	Nil
13	Vehicular Underpass	Nil	VUP-3	Ch 1.216, Ch 4.600 & Ch 8.255 (VUP)
14	Flyover	Nil	1 No.	Design Ch. 46.670
15	Toll Plaza	Nil	1 No.	Design Ch. 41.833

ES.8 MATERIAL INVESTIGATION

ES.8.1 Borrow Area Soil

For NH-927D, extensive surveys were conducted to locate the potential sources of borrow area soil required for the construction of embankment and subgrade. 13no. of borrow area locations are identified on both sides along the project road.

ES.8.1.1 Analysis of Results

Test results of Soil in borrow areas are generally Gravelly Sand with fractions of Silt and also a little clay at the locations 29+200, 80+200 and 102+000. Generally, the strata are non-

plastic. OMC values vary from 8.00 % to 18.00% and those of MDD vary from 1.78 gm/cc to 2.22 gm/cc. The CBR value at 97% MDD generally ranges from 9% to 31%.

ES.8.2 Fine Aggregates (Sand/Stone Dust)

7 Sand/ Stone Dust quarries were identified as the potential source of coarse aggregates required for road construction, the lead distance from the project vicinity is found in the range from Km 0 to Km 3.

ES.8.2.2 Analysis of Results

The fine aggregate samples collected as per IS 383 lies in zone I for all the locations. The fineness modulus of fine aggregate lies in the range 3.61 to 3.94 implies that sand from all the locations falls outside the specifications of MoRTH (Between 2.0 and 3.5). Specific gravity of these fine aggregate samples lies between 2.66 to 2.89.

ES.8.3 Coarse Aggregate

Detailed survey on the project was done and it was revealed that the stone quarries in this area and its corresponding leads are as follows:

- Stone Crusher, Lead 1.0 km from CH: 4+800 (RHS), Theba Village
- Stone Crusher, Lead 1.0 km from CH: 8+700 (RHS), Motu Thawariya Quarry
- Material Industries, Lead 1.0 km from CH: 12+100 (LHS), Vijrakhi Quarry
- Stone Crusher, Lead on road on CH: 55+000 (LHS), Makrani Sarosana
- Stone Crusher, Lead 2.0 km from CH: 98+100 (LHS), Jam Kandora Quarry, Rajkot.

ES.8.3.3 Analysis of Results

Test result of coarse aggregates satisfies the requirements of Los-Angeles's abrasion value, impact value, stripping value and Specific gravity and water absorption values as per MORTH requirements.

ES.9 ENVIRONMENT SCREENING AND PRELIMINARY ENVIRONMENTAL ASSESSMENT

ES.9.1 Environmental Clearance

As per Notification S.O. No. 2559(E) dated 22.08.2013 the expansion of National Highways greater than 100km length involving additional right of way or land acquisition greater than 40m on existing alignments and 60m on realignments or bypasses will require Environment clearance. This project highway having National Highway of length 47.572 km but it will not require additional right of way more than 40m for existing alignment. Hence project does not require Environment Clearance.

ES.9.1.1 Ecological Resources

The area passes through light vegetation cover of uniformly distributed trees along the road. Approximate 8000 number of trees/ plants of various species are present in the Right of way on existing road. It is tried to save trees along the road by improving the geometry of the road. These trees exist on both the sides along the road. By adopting eccentric widening one side trees can be saved. Many locations of project stretch have been realigned to improve the geometry of the road in such a way so that it also saves trees along the road.

ES.9.2 Forest

Trees along the road fall under Protected Forest area of 47.993 ha. Reserved forest in the project area is 4.773 ha. Therefore, Total Forest Area is 52.766 ha, for which Forest application has been submitted vide Proposal No. FP/GJ/ROAD/27083/2017.

ES.9.2.1 Wildlife and Bio-diversity

Project road does not pass through any national park / wild life sanctuary.

ES.10 SOCIAL ASSESSMENT AND PRELIMINARY LAND ACQUISITION/ RESETILEMENT PLAN

The project highways involve the total land required is about 213 Ha. for improving the geometry of the project stretch for bypass, realignments and curve improvement. It has been tried to avoid to resettlement of structure for acquisition in existing alignment for that at dense location bypasses and realignment has been proposed for further improvement.

During Public consultation, the people appreciated the proposed improvement in existing alignment for curves and improving the deficiencies of road.

ES.10.1 Land Acquisition Requirement

Table ES.21: Detail of Land Acquisition

S. No.	Additional Land Acquisition	Area in Ha.
1	Total Land Required	213 Ha
2	Available Land	115 Ha
3	Land to be Acquired	98 Ha
3a	Govt. land	39 Ha
3b	Private land	59 Ha

Table ES.23: Economic Internal Rate of Return (EIRR)

S. No.	Scenario	Condition	EIRR
1	5% Growth Scenario	Base Costs and Base Benefits	13.8%

The economic analysis carried out for 5% Growth Scenario results with **13.8% EIRR** as against minimum 12% (viability acceptance) for a period of 30 years & 12% discount rate.

ES.13 FINANCIAL ANALYSIS

The main objective of undertaking this study is to assess whether the project is financially viable or not. It is important to note that the proposal should be an attractive proposition for

private sector participation under Build, Operate and Transfer (BOT) system. The basic methodology followed for estimating the financial viability of the project is to calculate the FIRR (Financial Internal Rate of Return) on the investment for the project.

Following assumptions are taken into consideration for the financial analysis: -

- Debt – Equity ratio: - 70: 30
- Grant– 40%
- Concession period (Including 730 days construction period) – 22 years.
- Escalation – 5%
- Interest on Debt – 11.5%
- Loan Repayment period – 11 years
- Tax rebate – 10 years (100% exemption for 10 years out of block of 20 years).
- Depreciation by Straight line method - 100% for Concession Period.

Toll Plaza Locations & Tolling Length

The project road starts from the sections Kalavad to Jamnagar viz. Ch. 0+000 to Ch. 47+572. The tolling length as per the toll notifications consists of length of highway, structures having length more than 60m & bypass costing Rs 10 Cr. or more. As per the proposed project features the details are given below:

Table ES.24: Proposed Toll Plaza Locations and Effective Tolling Lengths

Toll Plaza Location Existing km	Length of Road (without structure) (km)	Length of Bypass (cost >10cr.) (km)	Length of Structures (>60 m) (km)	Total Tolling Length (km)
km 10+000	38.429	9.075	0.678	47.572

The toll charges have been calculated as per National Highways Fee (Determination of Rates and Collection) Rules, 2008, Amendment 2010, Amendment 2011, Amendment 2013 & Amendment 2014 and amendment thereafter. The estimated toll charges in year 2028-29 for both the tolling sections are as shown below:

Category of Traffic	Km 10+000
Passenger Car	105.00
Mini LCV	105.00
LCV's (4-Tyre & 6-Tyre)	165.00
Mini Bus	165.00
Standard Bus	350.00

Category of Traffic	Km 10+000
2 Axle Truck	350.00
3 Axle Truck	380.00
MAV (4 to 6)	550.00
HCM/EME	550.00
OSV (7 or more)	670.00

The tollable traffic for the base year 2024-25 at proposed toll plaza locations at Km 10+000 is 5014 nos.

ES.13.1 RESULTS

Table ES.25: FIRR Results for Concession Period 22 years

Scenario	Grant	Project IRR (%)	Equity IRR (%)
5% Growth Scenario	40%	7.60%	4.54%

The financial analysis of the project road has been carried out for a period of 22 years for 5% growth scenario. Since the base year tollable traffic is 5014 nos. at Km 10+000.

ES.13.2 CONCLUSION

The viability of the project has been examined for grant allocation of 40%. For the given set of conditions, the Equity IRR comes to be 4.54% as against 15% (viability), whereas the DSCR comes to be 0.71, as against minimum 1.0. Therefore, the project is found to be financially Non-viable on BOT (Toll) basis and recommended on EPC/HAM mode.



CHAPTER - 1

INTRODUCTION

CHAPTER - 1 INTRODUCTION

1.1 PROJECT BACKGROUND

The Indian Academy of Highway Engineers (IAHE) has been entrusted with the assignment of Project Management Consultancy Phase I including preparation of Detailed Project Report of selected stretches/corridors of National Highways for Two/ Four laning with paved shoulder configuration in the States of Maharashtra, Gujarat, Chhattisgarh, Rajasthan and Karnataka. Under this phase, Government of India felt the necessity of partially access controlled corridor between Dhoraji and Jamnagar through upgradation of a 105 km long section of NH-927D. The present SH-26 notified into NH-927D vide S.O. No. 1522(E) enclosed as **Annexure 1.1**.

The proposed improvements of Dhoraji-Jamnagar highway aims for:

- Important Interstate connectivity between Dhoraji to Jamnagar Port Centre.
- Connectivity to many headquarters/taluka place developed as business centre and Agriculture Marketing Yard.
- Better connectivity to important town Kalavad and Jamkandorna along the project corridor.
- Provide a platform for better economic and Industrial growth of the region.

IAHE has invited proposal for carrying out Feasibility Study and Detailed project preparation for upgrading to 2/4 lane with paved shoulders configuration of Dhoraji-Jamnagar section of NH-927D in the state of Gujarat (Package No: NH/IAHE/18).

The work for Consultancy Services for Preparation of Feasibility cum Detailed Design Report of Dhoraji-Jamnagar Section of NH-927D has been awarded to M/s Consulting Engineers Group Ltd., Jaipur vide IAHE/Admin/07/Project-MORT&H/2014-15/18 dated 14.05.2015. Accordingly, consultant has commenced the services on 29.05.2015 vide CEG/D-121/2015/79 dated 22.05.2015. After detail reconnaissance survey and preliminary option study Draft Inception Report has been submitted by consultant on 19.06.2015 vide CEG/D-121/2015/128. The comments on Draft Inception Report were issued vide IAHE/DPR/Tech/NH-IAHE-18/2015-16 dated 20.07.2015. The consultant after incorporating the comments on Draft Inception Report, Final Inception Report has been submitted vide CEG/D-121/2015/211 dated 29.07.2015. Accordingly, after completion of all Survey and Investigations, Draft Feasibility Report for the complete project has been submitted vide CEG/D-121/2015/308 dated 08.10.2015. The various presentations on Draft Feasibility Report and for finalization of alignment have been executed.

1. Presentation on 03.11.2015 with IAHE at Noida and It was decided by IAHE officials to finalize alignment with State PWD and Regional Office MoRTH and IAHE issued

- letter to CE-NH-PWD Gujarat to furnish the comments on Draft Feasibility Report vide IAHE/DPR/Tech/NH-IAHE-18/2015-16.
2. On 30.11.2015, a presentation was conducted on 30.11.2015 at CE-NH, R&B Dept. Secretariat, Gandhinagar.
 3. Further a meeting at Sachivalaya, Gandhi Nagar, Gujarat has been proposed on 06.02.2016 to finalize the alignment and comments on Draft Feasibility Report.
 4. A meeting and presentation on 24.02.2016 have been conducted at IAHE Noida and comments has been issued on 04.03.2016 and asked to take comments from state PWD and alignments finalization with project packaging Packages after due consultation with state PWD.
 5. The compliance of comments issued for meeting on 24.02.2016 dated 04.03.2016 has been made by consultant vide letter CEG/D-121/2015/606.
 6. Further State PWD/RO-MoRTH held presentation meeting at Secretariat Gandhi Nagar on 02.03.2016 and concluded that 2 lane paved shoulder configuration should be adopted for entire stretch and bypass are to be avoided.
 7. Further MoRTH New Delhi call a meeting on 28.04.2016 at CE(P4) MoRTH, Transport Bhawan, New Delhi to finalize the alignment and Project configuration for Two lane and Four lane.
 8. The MoRTH, New Delhi was issued Minutes of Meeting dated 28.04.2016 dated 09.05.2016 vide RW/NH/1203/07/2045/PS-4/GJ dated 09.05.2016 and directed for required statutory clearance and divide the project into packages for speedy Implementation. Based on traffic scenario, it is proposed to take the project in two lane paved shoulder configurations for whole stretch.
 9. On 10.05.2016, IAHE vide his letter IAHE/DPR/Tech/Misc/01/2015-16 dated 10.05.2016 issued to NHAI for stretches coming under Four laning and asked to expedite the comments on Draft Feasibility by RO-MoRTH and State B & R Deptt.
 10. Further MoRTH vide RW/NH-12037/02/201/PS-4/GJ dated 03.06.2016 issued latest guide line RW/NH-33044/37/2015/S&RR dated 26.05.2016 for development of project stretches for 2 lane and 4 lane and it is directed to take up the stretches for four lane having Traffic trigger 10000 PCU.
 11. The consultant has submitted the eligible four laning stretches as per New MoRTH guide line for which one section of this project NH-927D from km Jamnagar to Kalavad (Ext. Km 3+720 to Ext. Km 50+925) shall be eligible for four lane. The Proposal for the same was submitted by consultant vide CEG/D-121/2015/133 dated 13.06.2016.

The Final Feasibility report of package-2 has been submitted vide CEG/D-121/2015/493 Dated 19.12.2016. Accordingly, the DPR consultant incorporated the observations received

from IAHE on Draft Feasibility Report and it has been decided to divide project highway in two packages by considering the Traffic demand and pattern. The Package-1 is for Dhoraji-Jamkandorna-Kalavad section for two lane paved shoulder and Package-2 for Kalavad-Jamnagar section for four laning upgradation.

Further Draft DPR for Package-2 has been submitted on 09.08.2017.

Final DPR for Package-2 has been submitted on 06.07.2018.

Submission of Revised DPR proposal has been done on 18.02.2025

This report Represents Final Detailed Project Report for Package-2 i.e. Kalavad-Jamnagar Section with 4 lane Kalavad bypass.

1.2 THE PROJECT ROAD

National Highway No. 927D (NH 927D) lies in western India. Earlier it was SH-26 and recently converted into NH-927D. The project road connects Dhoraji in Rajkot district with Jamnagar in Gujarat. The project road for package-2 four lanning starts from km 50+925 (Shooting off point for Proposed Kalavad Bypass and ends at km 3+720 crossing with SH-25 (four lane Toll Road). The project road passes through in Jamnagar District only. The project road is passing through major Habitations like Kalavad, Vijarkhi, Khandera. The Key Map depicting the project road is presented in **Figure 1.1**.

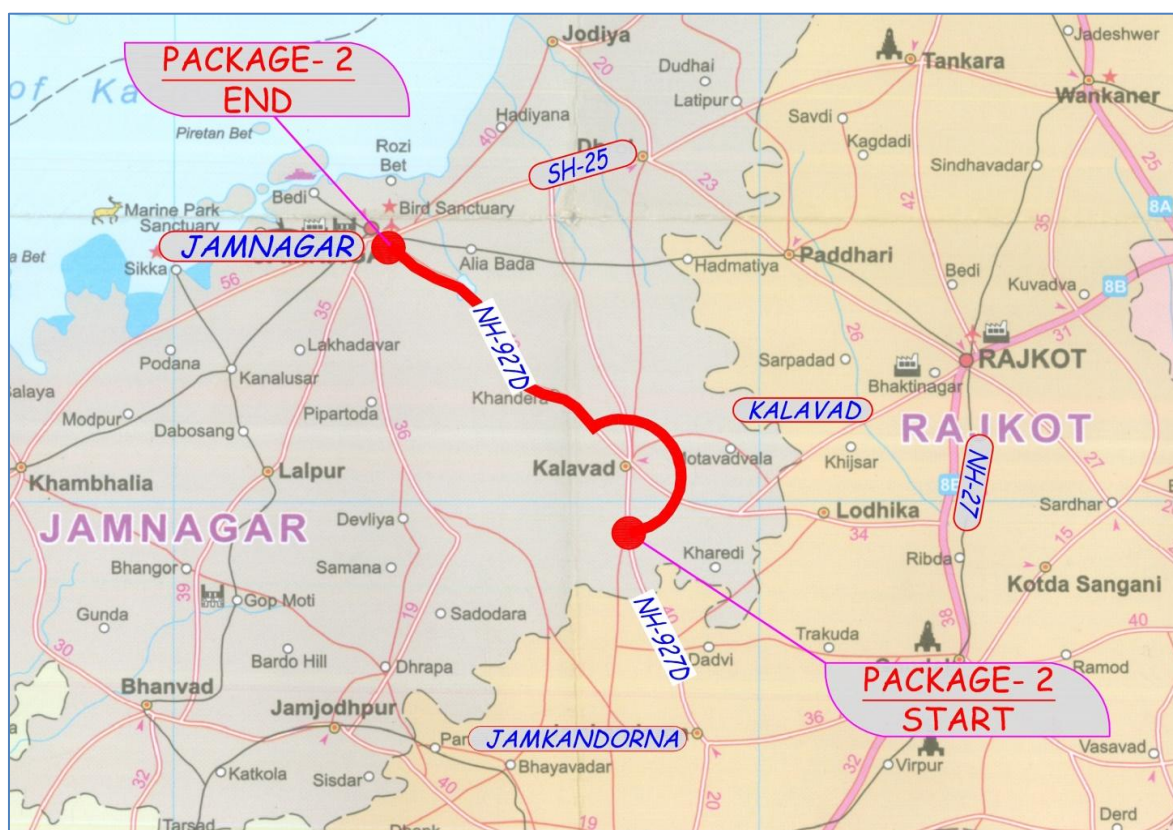


Figure 1.1: Index Map of Project Highway

1.3 OBJECTIVE OF THE CONSULTANCY SERVICES

The main objective of the consultancy service is to establish the technical, environmental, social, economical, and financial viability of the project and prepare detailed project reports for rehabilitation and upgrading of the existing road to 4 lane configuration.

The viability of the project will be established taking into account the requirements with regard to rehabilitation, upgrading and improvement based on highway design, pavement design, provision of service roads wherever necessary, type of intersections, rehabilitation and widening of existing and/or construction of new bridges and structures, road safety features, quantities of various items of works and cost estimates and economic analysis.

The Detailed Project Report would inter-alia include detailed highway design, design of pavement and overlay with options for flexible or rigid pavements, design of bridges and cross drainage structures and grade separated structures, design of service roads, quantities of various items, detailed working drawings, detailed cost estimates, economic and financial viability analyses, environmental and social feasibility, social and environmental action plans as appropriate and documents required for tendering the project on commercial basis for international/ local competitive bidding.

The DPR consultant shall ensure detailed project preparation incorporating aspects of value engineering, quality audit and safety audit requirement in design and implementation.

The consultant should, along with Feasibility Report, clearly bring out through financial analysis the preferred mode of implementation on which the Civil Works for the stretches are to be taken up. The consultant should also give cost estimates and tender documents along with Feasibility Report/ Detailed Project Report.

1.4 SCOPE OF THE CONSULTANCY SERVICES

- 1.4.1 As far as possible, the widening/improvement work to 4-lane with paved shoulder shall be done by taking additional right of way. The Consultant shall furnish land acquisition details (i.e. all necessary schedules as per L.A. act) as per revenue records/ maps for further processing of land acquisition. Consultant shall also submit 3a, 3A and 3D draft notification for acquisition of land.
- 1.4.2 Study the possible locations and design of toll plaza. Wayside amenities required on tolled highway shall also be planned. The local and slow traffic may need segregation from the main traffic and provision of service roads and fencing may be considered, wherever necessary to improve efficiency and safety.
- 1.4.3 Preparation of suitable proposals for widening/ improvement of the existing road to 4 lanes with paved shoulder with required at the appropriate time to maintain the level of service over the design period.

- 1.4.4 Environmental Impact Assessment, Environmental Management Plan and Rehabilitation and Resettlement Studies.
- 1.4.5 Obtaining all necessary clearance from concern agencies for implementation of project.
- 1.4.6 Preparation of the Bid Documents including schedule, based on the feasibility report, due to exigency of the project for execution if desired by IAHE. Assist the MoRTH/ IAHE and its Financial Consultant and the Legal Adviser by furnishing clarifications as required for the financial appraisal and legal scrutiny of the Project Highway and Bid Documents.
- 1.4.7 Preparation of separate documents at Feasibility stage/ DPR stage as per the financing options finalized like BOT, Annuity, and EPC during feasibility study stage.

1.5 STAGES OF SUBMISSION

The following reports and documents are to be submitted as per Terms of Reference: Up to Draft Feasibility stage the required report has been submitted for complete stretch from Dhoraji to Jamnagar for Two lane paved shoulder configuration. The report submission for this stretch is being submitted by this report as per clause 10.3 of stage-3 of Consultancy contract.

- Stage I
 - Quality Assurance Plan (QAP) Document (Already submitted)
 - Inception Report (IR) (Already submitted)
- Stage II
 - Feasibility Report (Draft Feasibility Report has submitted for complete stretch from Kalavad to Jamnagar)
 - Strip Plans and Clearances
 - Land Acquisition Report
- Stage III
 - Draft Detailed Project Report (DPR)
 - Final Detailed Project Report

Annexure 1.1

2

THE GAZETTE OF INDIA : EXTRAORDINARY

[PART II—SEC. 3(ii)]

टिप्पण : राष्ट्रीय राजमार्ग अधिनियम, 1956 (1956 का 48) और इसकी अनुसूची, भारत के राजपत्र में अधिसूचना संख्या का.नि.आ. 1180, तारीख 4 अप्रैल, 1957 द्वारा प्रकाशित की गई थी और इसे अधिसूचना संख्या का.आ. 689 (अ), तारीख 4 अप्रैल, 2011 द्वारा प्रतिस्थापित किया गया था और पिछली बार संशोधन अधिसूचना संख्या का. आ. 1089 (अ), तारीख 26 फरवरी, 2014 द्वारा किया गया था।

MINISTRY OF ROAD TRANSPORT AND HIGHWAYS NOTIFICATION

New Delhi, the 13th June, 2014

S.O. 1521(E). —In exercise of powers conferred by sub-section (2) of Section 2 of the National Highways Act, 1956 (48 of 1956), the Central Government hereby makes the following further amendment in the notification of the Government of India, in the Ministry of Road Transport and Highways published in the Gazette of India, Extraordinary, Part II, Section 3, Sub-section (ii) vide number S.O 689 (E), dated, the 4th April, 2011, namely:—

In the Schedule, for serial number 207, and entries relating thereto, the following shall be substituted, namely: -

(1)	(2)	(3)
207	68	The highway starting from its junction with NH-11 near Jaisalmer connecting Barmer, Sanchor in the State of Rajasthan, Tharad, Bhabar, Radhanpur, Kamalpur, Khakhhal, Roda, Dunawada, Patan, Chanasma, Mahesana, Kherva, Gojariya, Sama, Churada, Kuvadara and terminating at its junction with NH-48 near Prantij in the State of Gujarat.

[F. No. NH-14012/15/2013-P&M (Pt-22)]

MAYA PRAKASH, Director (P&B)

Footnote:—The National Highways Act, 1956 (48 of 1956) and the Schedule thereto was published in the Gazette of India vide notification number S.R.O. 1180 dated 4th April, 1957 and was substituted vide notification number S.O.689 (E), dated 4th April, 2011 and last amended vide notification number S.O. 1089 (E), dated 26th February, 2014.

अधिसूचना

नई दिल्ली, 13 जून, 2014

का.आ. 1522 (अ).—केन्द्रीय सरकार, राष्ट्रीय राजमार्ग अधिनियम, 1956) 1956 का) (48)से इसमें इसके पश्चात उक्त अधिनियम कहा गया है द्वारा (2) की उपधारा 2 की धारा (प्रदत्त शक्तियों का प्रयोग करते हुए, निम्नलिखित तालिका के स्तम्भ में (3) विनिर्दिष्ट प्रत्येक राजमार्ग को तत्संबंधी तदनुरूप स्तम्भ-में यथा (2) विनिर्दिष्ट राष्ट्रीय राजमार्ग घोषित करती है।

राजमार्गों,य राजमार्ग घोषित किया जाना हैजिन्हें अब इस अधिसूचना द्वारा राष्ट्रीय , को तालिका के स्तम्भ)1(,)2) और (3य राजमार्गों ओं तथा राष्ट्रीय राजमार्ग संख्यानई राष्ट्रीय ,ओंनई क्रम संख्या : क्रमशनिर्दिष्ट-में यथा (पित किया गया समझा जाएगा।स्था: अधिनियम की अनुसूची में अंतके विवरण के साथ उक्त

तालिका

क्र.सं .	नई राष्ट्रीय राजमार्ग संख्या	राष्ट्रीय राजमार्गों का विवरण
(1)	(2)	(3)
293	341	गुजरात राज्य में भीमासार के निकट रारा 41-के साथ अपने जंक्शन से प्रारंभ होकर अंजार, भुज, खावड़ा को जोड़ते हुए और धर्मशाला में समाप्त होने वाला राजमार्ग।
294	147ए	गुजरात राज्य में लिम्बदी के निकट रारा 47-के साथ अपने जंक्शन से प्रारंभ होकर सुरेन्द्रनगर, धर्मगाधरा को जोड़ते हुए और कुडा में समाप्त होने वाला राजमार्ग।
295	351	गुजरात राज्य में महुआ के निकट रारा 51-के साथ अपने जंक्शन से प्रारंभ होकर सवेरकुंडला, अमरेली, बागासारा को जोड़ते हुए और रारा 27-पर जेठपुर में समाप्त होने वाला राजमार्ग।

296	953	गुजरात राज्य में अहवा को जोड़ते हुए सोनगुध के निकट रारा 53-के साथ अपने जंक्शन से प्रारंभ होकर सरद, वाणी को जोड़ते हुए और महाराष्ट्र राज्य में पीपलगांव, बसवंत के निकट रारा 60-के साथ अपने जंक्शन पर समाप्त होने वाला राजमार्ग।
297	डी 927	गुजरात राज्य में धोराजी के निकट रारा 27-के साथ अपने जंक्शन से प्रारंभ होकर जंमकंदोरना, कलावड को जोड़ते हुए और जामनगर में समाप्त होने वाला राजमार्ग।

[फा.सं. एनएच-14012/15/2013-पीएंडएम)भाग-22(]

माया प्रकाश, निदेशक (पीएंडबी)

पाद टिप्पण : राष्ट्रीय राजमार्ग अधिनियम, 1956 (1956का (48 और इसकी अनुसूचीभारत के राजपत्र में , अधिसूचना संख्याका.नि.आ. 1180, तारीख ,अप्रैल 41957 द्वारा प्रकाशित की गई थी और इसे अधिसूचना संख्या का .आ.689) अ(, तारीख 4अप्रैल ,2011 द्वारा प्रतिस्थापित किया गया था और पिछली बार संशोधन अधिसूचना संख्या का .आ .1089 (अ), तारीख ,फरवरी 262014 द्वारा किया गया था।

NOTIFICATION

New Delhi, the 13th June, 2014

S.O. 1522 (E).—In exercise of the powers conferred by sub-section (2) of Section 2 of the National Highways Act, 1956 (48 of 1956) (hereinafter referred to as the said Act), the Central Government hereby declares each of the highways specified in the column (3) of the Table below to be a national highway, as specified in the corresponding column (2) thereof.

The highways, now declared to be national highways by this notification, shall be deemed to be inserted in the Schedule to the said Act with the new serial numbers, the new national highways numbers and the description of the national highways thereof, as indicated in columns (1), (2) and (3) respectively, of the Table.

TABLE

Serial No.	New National Highway No.	Description of National Highways
(1)	(2)	(3)
293	341	The highway starting from its junction with NH-41 near Bhimasar connecting Anjar, Bhuj, Khavda and terminating at Dharmshala in the State of Gujarat.
294	147A	The highway starting from its junction with NH-47 near Limbdi connecting Surendranagar, Dhrangadhra and terminating at Kuda in the State of Gujarat.
295	351	The highway starting from its junction with NH-51 near Mahuva connecting Saverkundla, Amreli, Bagasara and terminating at Jetpur on NH-27 in the State of Gujarat.
296	953	The highway starting from its junction with NH-53 near Songudh connecting Ahwa in the State of Gujarat, Sarad, Vani and terminating at its junction with NH-60 near Pimpalgaon Baswant in the State of Maharashtra.
297	927D	The highway starting from its junction with NH-27 near Dhoraji connecting Jamkandorna, Kalavad and terminating at Jamnagar in the State of Gujarat.

[F. No. NH-14012/15/2013-P&M (Pt-22)]

MAYA PRAKASH, Director (P&B)

Footnote : The National Highways Act, 1956 (48 of 1956) and the Schedule thereto was published in the Gazette of India vide notification number S.R.O. 1180 dated 4th April, 1957 and was substituted vide notification number S.O.689 (E), dated 4th April, 2011 and last amended vide notification number S.O. 1089 (E), dated 26th February, 2014.



CHAPTER - 2

OVERVIEW OF MORTH/ IAHE

CHAPTER - 2

OVERVIEW OF MORTH/ IAHE

2.1 MORTH / IAHE ESTABLISHMENT

The Ministry of Road Transport and Highways (MoRTH), an apex organization under the Government of India, is entrusted with task of formulating and administering, in consultation with other Central Ministries/ Departments, State Governments/ UT Administration, Organizations and individuals, policies for Road of Transport, National Highways and Transport Research with a view to increase the mobility and efficiency of the Road Transport system in the country. The Ministry has two wings: Road wing and Transport wing. The Road wing deals with development and maintenance of National Highways and Transport wing deals with matter relating to Road Transport. The MoRTH also extend technical and financial support to State Government for the development of state roads apart from evolving standard specifications for roads and bridges in the country. It serves as a repository of technical knowledge on roads and bridges. The Ministry has taken up a massive programme of up-gradation and development of National Highways. Out of 70548 km of total existing arterial routes of National Highways network, about 33455 km are proposed to be widened to 4/6 lanes depending upon the traffic to international standards in various phases under National Highways Development Project (NHDP). This work is entrusted to the National Highway Authority of India (NHAI) by the Ministry. The total cost of NHDP has been estimated to be about Rs.54000 Crore and is being financed through cess on petrol and Diesel, External Assistance like Asian Development Bank and World Bank etc, Market Borrowings through securities receipts and Private Sector Participation (BOT). The cost incurred by NHAI/ Private Sector is being recovered through collection of toll on users.

Indian Academy of Highway Engineers (IAHE): The said project for Consultancy Services for Project Management Phase-I including preparation of Detailed Project Report for up gradation of Junction with NH-27 near Dhoraji-Jamkandorna, Kalavad-Jamnagar section of NH-927D in the state of Gujarat to two/ four lane with paved shoulder configuration (Package no - NH/IAHE/18) is being implemented by IAHE as agency of MoRTH. IAHE is the apex training institute set up to address the training needs of Highway and Bridge Engineers in the country. It was set up as an Institute in the year 1983 with the primary objective to fulfill the need for training of highway engineers at the entry level and during the service. The IAHE has been registered as a Society in January 1983.

- Started Operations from a rented accommodation in Delhi since April 1985 with changed name of NITHE. Continued to operate in Delhi till Sept, 2001 and thereafter shifted to its own campus at NOIDA, UP w.e.f. Oct, 2001.

- Organizes training for Highway Sector Engineers and professionals of Central / State Govts., Public & Private sectors.
- Also imparts training to Highway Professionals from Abroad under various training programs-SAARC countries, Colombo Plan countries and Afro-Asian countries, etc.

2.2 IAHE GOVERNING BODY

Table 2.1: IAHE Governing Body

1	Secretary (RT&H)	Chairman
2	Director General (Road Development) & Special Secretary, Ministry of Road Transport & Highways	Vice Chairman
3	ADG (Bridge & Roads), Ministry of Road Transport & Highways	Member
4	ADG (Roads), Ministry of Road Transport & Highways	Member
5	Financial Adviser & Addl. Secretary, Ministry of Road Transport & Highways	Member
6	President, Indian Roads Congress (IRC)	Member
7	A Nominee of the Ministry of HRD, Deptt. of Higher Education	Member
8	Director General Border Roads Organisation	Member
9	Director, Central Road Research Institute	Member
10	Director, IAHE, Ministry of Road Transport & Highways	Member
11	Member (Technical), National Highway Authority of India	Member
12	Director, Indian Institute of Technology(IIT), Delhi	Member
13	Joint Secretary (Transport)	Member
14	Joint Secretary (Highways)	Member
15	Secretary (PWD), J&K	Member
16	Chief Engineer (PWD) & Chief Project Officer, Karnataka State, Highway Improvement Project (KSHIP), Government of Karnataka	Member
17	Secretary (Highways), Government of Tamil Nadu/ Director, HRS, Chennai	Member
18	Chief Engineer (Panchayat) & Addl. Secretary, Government of Gujarat	Member
19	Chief Engineer (PWD), Manipur, PWD	Member

2.3 PROJECT FINANCING & COST RECOVERY MECHANISMS

MORTH proposes to finance its projects by a host of financing mechanisms. Some of them are as follows:

1. The Government of India-Budgetary Allocation

The Government of India introduced a Cess on both Petrol and Diesel. This amount at that time (at 1999 prices) came to total of approximately Rs. 2,000 crores per annum. Further, Parliament decreed that the fund so collected were to be put aside in a Central Road Fund (CRF) for exclusive utilization for the development of a modern road network. The development work that it could be tapped to fund, the agencies to which it was available were clearly defined as:

- Construction and Maintenance of State Highways by State Governments.
- Development of Rural Roads by State Governments.
- Construction of Rail Over Bridges by Indian Railways.
- Construction and Maintenance of National Highways by NHDP and Ministry of Road Transport & Highway.

Today, The Cess contributes between Rs. 5 to 6 thousands crores per annum towards NHDP.

2. Loan Assistance from International Funding Agencies

Loan assistance is available from multilateral development agencies like Asian Development Bank and World Bank or Other overseas lending agencies like Japanese Bank of International Co-Operation.

3. Market Borrowing

MoRTH proposes to tap the market by securities cess receipts.

4. Private Sector Participation

Major policy initiatives have been taken by the Government to attract foreign as well as domestic private investments. To promote involvement of the private sector in construction and maintenance of National Highways, Projects are offered on Build Operate and Transfer (BOT) basis to private agencies. After concession period, which can range up to 30 years, this road is transferred back to MoRTH by the Concessionaries. MoRTH funds are also leveraged by the setting up of Special Purpose Vehicles (SPVs). The SPVs borrow funds and repay these through toll revenues in further. Some more models have emerged for better leveraging of funds available with MoRTH such as Annuity, which is a variant of BOT model.

5. Government Policy Initiatives

Policy Initiatives for Attracting Private Investment

- Government will carry out all preparatory work including land acquisition and utility removal. Right of Way (ROW) to be made available to concessionaires free from all encumbrances.
- MoRTH/GoI to provide capital grant and 30% relief for next 5 years, which may be availed of in 20 years.
- Concession period allowed up to 30 years.
- Arbitration and Conciliation Act 1996 based on UNICITRAL provisions.
- In BOT projects entrepreneur are allowed to collect and retain tolls.
- Duty free import of specified modern high capacity equipment for highway construction.



CHAPTER - 3
SOCIO-ECONOMIC PROFILE OF THE
PROJECT INFLUENCE AREA

CHAPTER - 3

SOCIO-ECONOMIC PROFILE OF THE PROJECT INFLUENCE AREA

3.1 INTRODUCTION

The project influence area is considered to be the district through which the Corridors road is passing. National Highway No. 927D (NH 927D) lies in western India. Earlier it was SH-26 and recently converted into NH-927D. NH-927D connects Dhoraji in Rajkot district with Jamnagar in Gujarat. The project length in which 72/200 km lies in Jamnagar district and remaining length lies in Rajkot district. The present SH-26 notified into NH-927D vide S.O. No. 1522(E).

This report pertains to Package-2 of Kalavad-Jamnagar section finalized for Four lane because of traffic triggers 10000 PCU as per New MORTH Policy from Ex. Km 50+925 to Km 3+720 of NH-927D. Total Design Length for four lane stretch is 47.572 km.

Government of India felt the necessity of partially access controlled corridor between Kalavad and Jamnagar through up gradation of Kalavad-Jamnagar section of NH-927D. The proposed improvements of Kalavad-Jamnagar highway aims for:

- Important Interstate connectivity between Dhoraji to Jamnagar Port Centre.
- Connectivity too many headquarters / taluka place developed as business centre and Agriculture Marketing Yard.
- Better connectivity to important town Kalavad along the project corridor.
- Provide a platform for better economic and Industrial growth of the region.

This chapter contains the socio-economic profile for the state of Gujarat as well as the project-impacted districts for the purpose of providing a contextual background to understand the social impacts of the proposed Project. The remaining information has been provided as a supplement for the contextual background. The Key Map depicting the project road is presented in **Figure 1.1 in Chapter-1**.

3.1.1 Existing Road

The project highway is passes through major town Kalavad, Haripar, Khandhera, Modpar, Vijarkhi and Theba in Jamnagar District.

3.1.2 Right of Way

As per the details obtained from the State PWD, the Right of Way is 24m through the project stretch.

3.2 DEMOGRAPHIC FEATURES

The Land of the Legends, stands bordered by Pakistan and Rajasthan in the north east, Madhya Pradesh in the east, and Maharashtra and the Union territories of Diu, Daman, Dadra and Nagar Haveli in the south. The Arabian Gujarat is located on the western coast of India and has the longest coastline of 1,600 km in the country. The state shares its borders with Rajasthan, Madhya Pradesh, Maharashtra and the Union Territories of Daman & Diu and Dadra & Nagar Haveli. The Arabian Sea borders the state both to the west and the south-western borders the state both to the west and the south west.

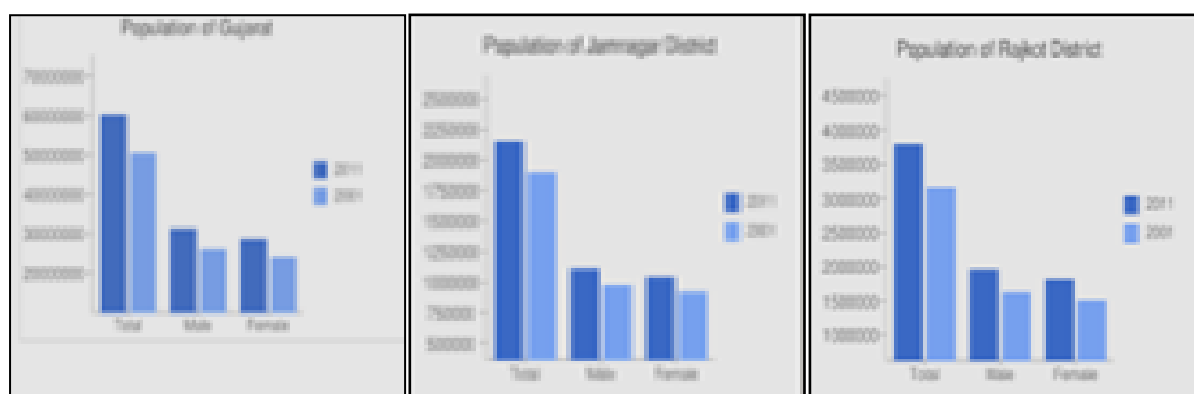
3.2.1 Population

Total population of Gujarat as per 2011 census is 60,439,692 of which male and female are 31,491,260 and 28,948,432 respectively. **Jamnagar** had population of 2,160,119 of which male and female were 1,114,192 and 1,045,927 respectively. **Rajkot** district had population of 3,169,881 of which male were 1,642,018 and remaining 1,527,863 were females. **Table 3.1** and **Figure 3.1** show the demography of Project Influenced Area in 2011.

Table 3.1: Demography of Project Influenced Area in 2011

Section	Project	Jamnagar	Rajkot	Gujarat
Dhoraji-Jamnagar	Area	67.500 km	35.300 km	-
Population	2506856	2,160,119	3,169,881	6,04,39,692
Population density per sq. km.	217	152	340	308
Decadal Growth	15.7	13.44%	20.02%	19.28 %
Male	1295440	1,114,192	1,642,018	3,14,91,260
Female	1211417	1,045,927	1,527,863	2,89,48,432
Sex Ratio	942	939	949	919
Percentage of total population	4.5	3.57%	6.29%	4.99%
Child sex Ratio (0-6)	895	904	879	890
Literacy Rate	74.0	73.65%	74.65%	78.03%
Male Literacy	82.0	81.50%	83.01%	85.75%
Female Literacy	65.5	65.33%	65.93%	63.31%
Scheduled Caste Population (in %)	8.0	8.13%	7.71%	6.7
Scheduled Tribe Population (in %)	0.5	0.55%	0.42%	14.8%
Urban Population	49.5	44.95%	58.19%	42.06%
Rural Population	50.5	55.05%	41.81%	57.04%

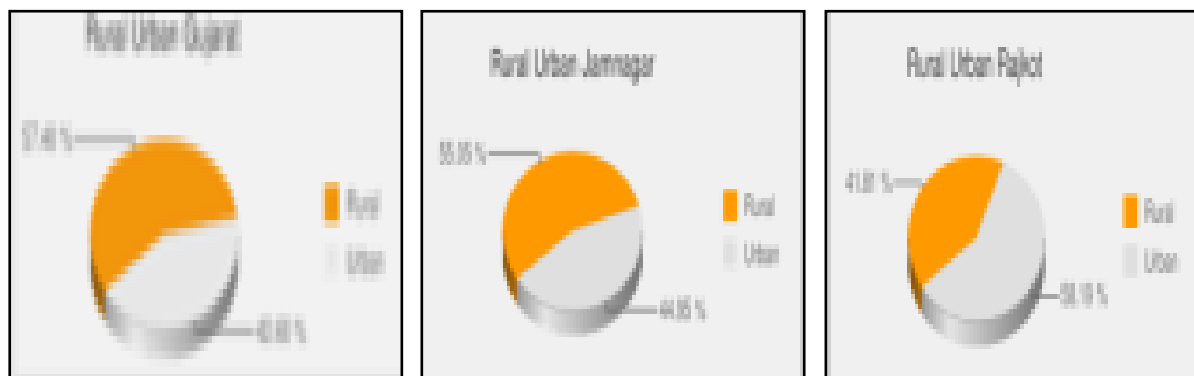
Source: Primary Census Abstract 2011



Source: Primary Census Abstract 2011

Figure 3.1: Demography of Project Districts and State

Total area of Gujarat is 196,244 Sq.km. Density of Gujarat is 308 per sq.km which is lower than National average 382 per sq.km. Census 2011 shows that density of Jamnagar district is 152 people per sq.km and Rajkot district density of 2011 is 340 people per sq.km of the total population of Gujarat state, around 57.40 percent live in the villages of rural areas. The population of rural areas of Gujarat state was 34,694,609. As per 2011 census, 55.50% population of Jamnagar districts lives in rural areas of villages. The total Jamnagar district population living in rural areas is 1,189,054. In 2011 census 41.81% population of Rajkot district lives in rural areas of village. **Figure 3.2** shows Rural & Urban population of, where project road traverses.



Source: Primary Census Abstract 2011

Figure 3.2: Rural & Urban population of Project Districts and State

Gujarat State had 42.60 % people live in urban regions. The total figure of population living in urban areas is 25,745,083. In 2011 district Jamnagar had 44.95% lives in urban regions of Rajkot district 58.19% lives in urban regions of the district in 2011 as per census.

Sex ratio in Gujarat is 919 i.e. for each 1000 male which is below national average of 940 as per census 2011. With regards to sex ratio in Jamnagar, it stood at 939 per 1000 male

compared to 2001 census figure of 941. Sex ratio in Rajkot, it stood at 927 per 1000 male compared to 2001 census figure of 930.

The total population growth in this decade was 19.28 percent while in previous decade it was 22.48 percent. The population of Gujarat forms 4.99 percent of India in 2011. In the previous census of India, Jamnagar district recorded increase of 21.79 percent to its population compared to 1991. In the previous census of India 2001, Rajkot district recorded increase of 26.08 percent to its population compared to 1991.

Literacy rate in Gujarat has been upward trend and is 78.033 percent as per 2011 population census. Of that, male literacy stands at 85.75% while female literacy is at 63.31 percent. The literacy rates for both sexes in urban areas are, as expected, much higher than for those in rural areas.

3.2.2 Vulnerable Population

The vulnerable population of the project districts and state is analyzed and given in this section.

Jamnagar district had 154819 schedule cast populations and Rajkot district schedule cast population is 244364 which are 8.13% & 7.71% respectively. As per 2011 census, Gujarat State had 40,74,447 scheduled caste population, which is 6.74 percent of the total population.

Jamnagar district has 10459 schedule tribe populations which is 0.55% of the total population. District of Rajkot has 13163 of scheduled tribe population which is 0.42% of the total population. The Scheduled Tribe population of Gujarat State had 89,17,174 which is 14.8% of the total population.

3.3 THE SOCIAL SERVICES

In order to strengthen various basic amenities either area based or population based, the Social and Community Programmes are required to be geared up at State level as well as district level so as the life of the people can be improved, Additional efforts in important sectors like health, education, women & child welfare, labour, environment, water supply, and sanitation, social welfare, rural housing, village & cottage industries etc. are required to bring significant improvement in the Human Development of the State. With a view to achieve the above mentioned objectives, various initiatives have been taken by the State Government.

In terms of overall social development, Gujarat has many more miles to cover to ensure that its economic growth translates into improved and sustainable human development. Although there has been significant improvement in terms of health and education infrastructure over the years, the challenge remains to further improve the access to these basic services to by communities in remote and marginalized rural areas.

- In recent years, social infrastructure in areas such as **health and education** has improved significantly. This can, to some extent, be attributed to the increased presence of the private sector in the state. However, it is crucial to ensure that access to services is enhanced for those who need it the most, especially the marginalized tribal communities living in hard-to-reach areas.
- Issues of quality and access to basic services by the poor have emerged as a priority for the State Government. Responding to this, Gujarat's 12th Five Year plan has enhanced allocations for the social sector by 40 per cent. This will not only help address the infrastructural gaps, but will also be instrumental in meeting the critical needs and entitlements of children and women.

3.3.1 Education Infrastructure

The education department of the state pays special attention to the improvement of elementary education in Gujarat. The state government has also launched the district primary education program for making primary education compulsory and free for all students up to a certain age limit. It has also taken up several measures for checking the rate of dropout at schools in Gujarat. The same uniform structure of 10+2 education is followed in the schools of Gujarat. Saurashtra University is a major university. The university is well known for several schools including private, government granted schools. Project influenced.

Rajkot district has Primary Schools 1845, Secondary Schools 426, and Higher Secondary is 40. There are 5 Engineering Colleges in the district, ITIs 17 offering courses and 7 Polytechnic.

Jamnagar has many schools including private, government granted schools. Primary Schools 1316, Secondary Schools 156, and Higher Secondary are 45. The M.P. Shah Medical College is considered to be one of the top colleges in India for Medical studies. The Gujarat Ayurved University in Jamnagar is considered to be the best university in the world for Ayurvedic studies & has students from all around the globe. Besides this, there are several colleges for arts, commerce and science.

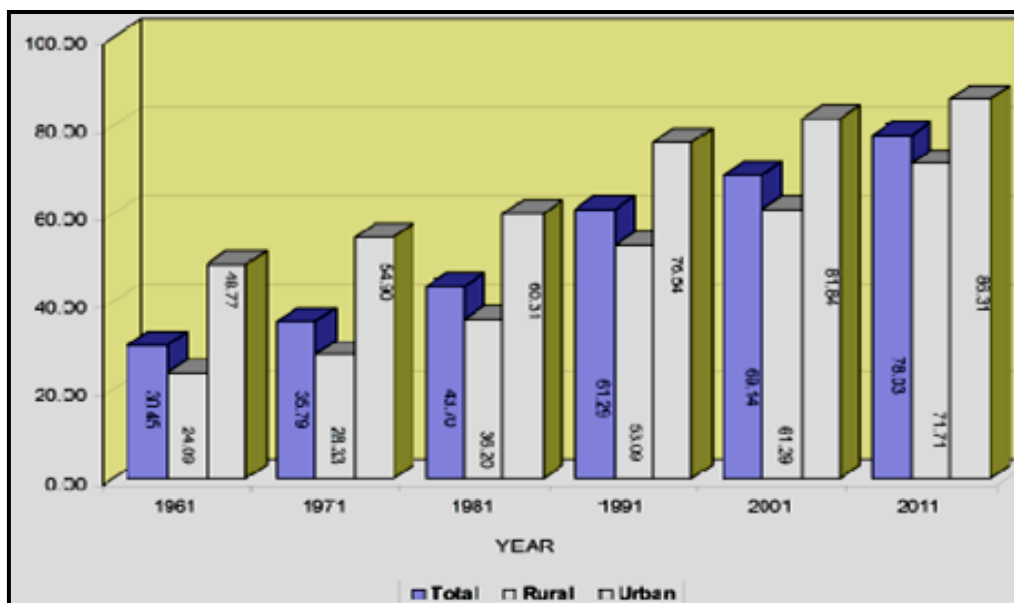
3.3.2 Literacy

Average literacy rate of project influence area in 2011 was 74% compared to 66.48% of 2001. If things are looked out at gender wise, male and female literacy were 82% and 65.5% respectively.

Average literacy rate of Jamnagar in 2011 was 73.65% compared to 66.48% of 2001. If things are looked out at gender wise, male and female literacy were 81.50% and 65.33% respectively.

In Rajkot district literacy rate in 2011 were 80.96% compared to 74.16% of 2001. Gender wise male and female literacy were 87.07% and 74.43%. Literacy in Gujarat State (1961-2011) Shown in **Figure 3.3** below.

The Literacy rate of Gujarat is 78.33 % which is higher than the all India average of 68.84%. The state has 51989 recognized government schools with primary and upper primary grades. The state is having total enrolment of 106`462 at the primary level of which the girls constitute 46.57% of the total enrolment.



Source: Statistical Abstract of Gujarat State- 2011

Figure 3.3: Literacy in Gujarat State (1961-2011)

One, improvements in literacy have been quite impressive especially among girls in the Decade of 1991-2001 and one can surmise optimistically that at long last a corner has been turned. The achievement is both because the demand for education has increased and the supply has also improved in most parts of the state.

3.4 ECONOMIC FEATURES

State Domestic Product (SDP) in Common Parlance know ad “ State Income” is a measure in monetary terms of the volume of all goods and services produced during a given period of time within the geographical boundaries of the state, accounted without duplication. This is the most important single economic indicator used to measure the growth and study the structural changes taking place in the economy. SDP estimates over a period of time reveal the extent and direction of the changes in the level of economic development. Sectoral composition of SDP gives an idea about the relative position of different sectors in the economy over a period of time, which not only indicates the real structural changes taking place in the economy, but also facilitates in formulation of the plans for overall economic development.

The Per Capita Net State Domestic Product, also Known as per capita income is used to determine both the absolute and relative performance of the state economy. It is also considered as an important tool to measure the regional disparities.

The state is among the top six major state economics and it contributes about 7.0 percent to the GDP at National level during the year 2009-10, though the states share to India's population is about 4.99 percent. For the Eleventh Five Year plan, a very high growth target of 11.2 percent has been set for Gujarat State by Planning commission Government of India. The State economy has been measured in terms of the Gross State Domestic Product (GSDP) at factor cost at constant prices as well as at Current prices. This is the most important single economic dictator used to measure the growth and to study the structural changes taking place in the economy.

Gross State Domestic Product (GSDP) at factor cost at constant (2004-05) prices in 2009-10 has been estimated at Rs. 331633 crore as against Rs. 300847 crore in 2008-09 registering a growth of 10.2 percent during the year. At current prices, GSDP at factor cost in 2009-10 has been estimated at Rs. 429356 crore as against Rs. 367745 core in 2008-09, registering a growth of 16.8 percent during the year. The higher growth in the economy during the year 2009-10 can be mainly attributed to manufacturing electricity, construction and communication sectors, which have contributed 11 to 34.6 percent growth during 2009-10 at constant (2004-05) prices.

The performance of the State economy in terms of GSDP in absolute values and percentage change over previous year at current and at constant (2004-05) prices are presented below:

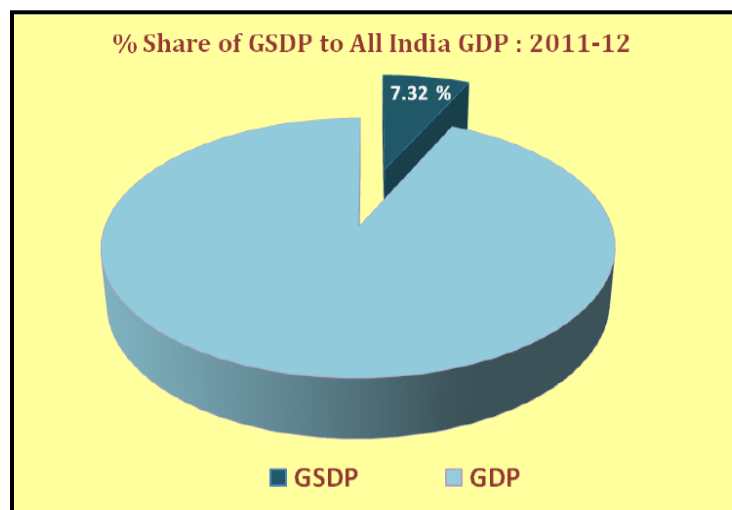
Table 3.2: GSDP at Current and Constant (2004-05)

Year	Gross State Domestic Product			
	Current Prices	Growth	Constant Price	Growth
2004-05	203373	-	203373	-
2005-06	244736	20.3	233776	14.9
2006-07	283693	15.9	253393	8.4
2007-08	329285	16.1	281273	11.0
2008-09	367745	11.7	300847	7.0
2009-10	429356	16.8	331633	10.2
2011-12	611767	15.3	398884	8.5

(Prices Value in Rs. Crore and Growth in percent) *Provisional, ** Quick Estimates

Source: State Domestic Product, Gujarat State

Gujarat is very strong in the petroleum sector and is considered the petro capital of India. The state attracted cumulative FDI worth US\$ 9.6 billion from April 2000-May 2014 and is the second highest recipient of FDI in India after Maharashtra. At current prices, Gujarat's gross state domestic product (GSDP) was about US\$ 123.4 billion over 2012-13. **Figure 3.4** Shows percentage share of GSDP to all India: 2011-12.



Source: State Domestic Product, Gujarat State

Figure 3.4: Percentage Share of GSDP to All India: 2011-12

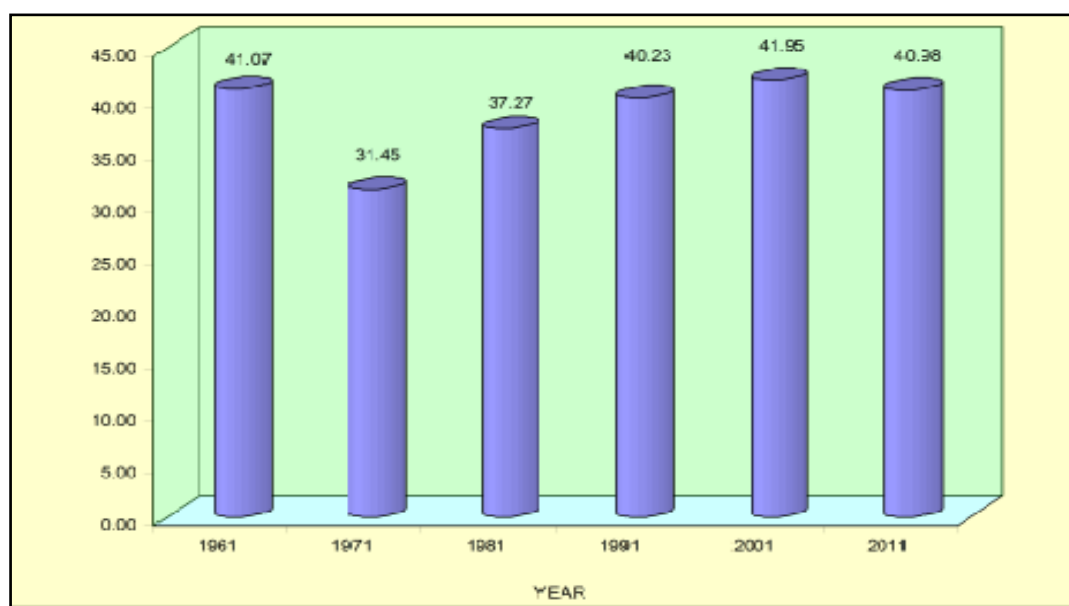
3.4.1 Distribution of Population by Workers and Non-Workers

Work participation rate is 41.0% of the total population in **Gujarat State** and in view of districts **Jamnagar & Rajkot work participation** is 8,47,440 and 14,79,050 respectively. Participation rate in project influence districts Jamnagar & Rajkot district is 33.39% -34.82% the percentage scenario of Non-Workers in State of Gujarat is 59.02% and in districts of Jamnagar & Rajkot are 60.77% and 61.12% respectively. **Table 3.3** and **Figure 3.5** show the Gujarat State Work Participation in 2011.

Table 3.3: Work Participation in Gujarat State in 2011

Section	Work Participation	Gujarat	Jamnagar	Rajkot
Dhoraji-Jamnagar	Work Participation Rate	40.97%	39.02%	38.09%
	Total Worker	40.98%	39.23%	38.88%
	Main Worker	33.70%	33.39%	34.82%
	Marginal Worker	7.28%	5.84%	4.05%
	Non Worker	59.02%	60.77%	61.12%

Source: Statistical Abstract of Gujarat State- 2011



Source: Statistical Abstract of Gujarat State- 2011

Figure 3.5: Total Worker population Ratio

3.5 INFRASTRUCTURE

Infrastructure refers to the fundamental facilities and systems serving a country, city, or area, including the services and facilities necessary for its economy to function. It typically characterizes technical structures such as roads, bridges, tunnels, water supply, sewers, electrical grids, telecommunications, and so forth, and can be defined as "the physical components of interrelated systems providing commodities and services essential to enable, sustain, or enhance societal living conditions."

A discussion of infrastructural development has to recognize: (1) The regional specialization of the State's economy and hence of the space that is possible and desirable for the region in question; and also (2) the level of overall economic development as indicated by the per capita income GDP and assess whether infrastructural services like those which are final consumption goods drinking water, municipal infrastructure, road services and such like are adequate. It would also have to outline the actions required for the adequate development of infrastructure.

3.5.1 Infrastructure in Gujarat State

Gujarat also known as Jewel of the West is the fastest growing state of India and it's a country in itself having all the resource within. It is also the role model state for rest of India in terms of Infrastructure Projects, Tourism and Economy. Gujarat state has ancient history of Indus Valley Civilization, world's first seaports Lothal and an archaeological site Dholavira.

Gujarat has a robust Infrastructure and is pioneer in Public-Private partnership. It takes to its credit as ‘Asia’s Biggest’ Investment Infrastructure Opportunity Centre.’ Gujarat state have strategically developed very efficient and cost affective infrastructure which boost states Urban and Industrial growth.

Gujarat is well-known for its double digit economic growth, which is much higher than the national growth rate besides providing excellent infrastructure and basic services to its citizen. The State has excellent road connectivity to all villages, large number of small and large ports well distributed along with 1700 km long coast, 24 hours power supply, State-wide water supply grid, excellent educational institutions, healthcare facilities, marketing yards, State-wide fiber optic network connecting all villages, etc. With best infrastructure in the country, coupled with Good Governance, Gujarat has become the hot destination for investors not only in the country but in this part of world. Its relentless quest for a larger image of Gujarat with all round development is foreseen bearing fruits of success. As one of the youngest States of the Indian Federation, Gujarat’s track record has shown impressive Development which make it a ‘Growth Engine of Gujarat.’

3.5.2 Industrial Development

Gujarat is located on the western coast of the Indian Peninsula. It has the longest coastline in the country of about 1600 kms. Therefore, Gujarat plays host to foreign trade and is a natural ‘**Gateway**’ to the fast growing economy. Conducive business environment, abundance of natural resources, skilled and semi-skilled man power, proximity to markets, responsive administration are a few reasons why Gujarat has turned a ‘Leader.’ A steady implementation of structural reforms to make Gujarat shine with its ‘Vibrant Economy’ is steadfastly growing at 15% of Industrial Growth with 18% of Country’s Industrial Investment in Gujarat. A large part of the investments that Gujarat realized, especially in organised industries, could not have gone elsewhere. This is true for instance of the public and private sector investment in oil, and petrochemicals and downstream chemical units.

The state of Gujarat is one of the highly industrialized states in India with its reputation of being a highly investor-friendly state. The state has a proven track record of attracting high volumes of investment becoming the most favored investment destination in India. In the backdrop of these developments, the Government of Gujarat has declared Industrial Policy - 2009. And after series of respective studies and meetings new industrial policy will be declared shortly.

The new Industrial Policy - 2009 with its holistic approach would identify specific interventions across sectors which would facilitate in fostering significant growth and in the process to attract global investments. The new industrial policy has been formulated with the primary policy objectives of:

1. Facilitate investments in the state.
2. Employment generation and Employability enhancement.
3. Adherence to high quality standards.

During the period before 1991 attracting investment in Gujarat, especially manufacturing investment was largely dependent upon the ability to offer low cost land, supporting physical infrastructure, a benign or nurturing environment in terms of industrial promotion, a politics that allowed labour flexibility to the extent possible under national law and an administrative machinery that was geared to remove many of the hurdles that industries faced in attracting investment elsewhere in the country.

3.5.3 Human Development

Poverty levels while much lower than in the rest of India should have been even lower given the high per capita SDP of the state. The state's performance on many of the human development indicators but especially morbidity, life expectancy, gender, and most importantly literacy has been poorer than that of many states, and adjusted for its higher income, it would be much worse than is indicated by absolute values. Inequality in income distribution is likely to be much higher than in other states.

The nature of physical infrastructure development has an indirect influence on human development. Rural roads that increase access to urban functions and services for rural people, and electricity distribution both of which, are important determinants of the quality of life in rural areas.

3.5.4 Rural and Urban Development

Gujarat has a host of Government Agencies looking after the development of Infrastructure facilities like roads, ports, power, Industrial parks, etc. As a front runner in economic development, the State has set an example worth emulation and has embarked upon Infrastructure development with '**World Class Infrastructure**' charting the roadmap to a future as "**Gujarat – The World Class Growth Engine.**"

Infrastructure development in a state is importantly determined by the policies, capacities and actions of the state government more than is overall economic development. The relative autonomy for the state and the lower levels of government is much larger in because the constitutional division of responsibilities between state and the centre specifies many of the infrastructure areas to be with the state government. Even more importantly the economics of infrastructure-especially the locational aspects and localization influences are strong. Typically the products and services of infrastructure, unlike other sectors are consumed locally. Thus irrigation water, town and city services, electricity, roads (except national highways), industrial services and estates, are in the states portfolio. Oil and gas, railways and ports (where both states and the centre have roles), and telecom are with the centre.

The social infrastructure areas are even more with the state government, the impact of investments is crucially dependent upon the level of economic development besides the local culture and preferences. The impact of investments in education in the south has been somewhat higher than in states like Gujarat and Rajasthan, but the cultural aspect should not be exaggerated.

3.5.5 Villages and their Connectivity by Road

Perhaps the most crucial infrastructure is connectivity of habitats by road and it is here that state governments can make a big difference. While there are few villages in India that are not connected by roads, their quality varies considerably. The Prime Minister's Gram Sadak Yojana (PMGSY) given the large outlays and some organizational innovation such as, transparency and performance monitoring, has been significantly better than the run of the mill programmes supported by the centre. Gujarat in comparison to its peers has done well in improving rural connectivity. Gujarat has a low population density except in the southern parts of the state, and that too, only the Golden Corridor. In Saurashtra and North Gujarat despite the lower density which reduces the social returns on roads, the connectivity is excellent and most villagers can easily reach urban places to access services like emergency healthcare.

3.5.6 Tourism

With the announcement of a National Tourism Policy in 2002 and the revival of the economy, tourism again picked up in the country and India has emerged as one of the five most important destinations in the world according to Lonely Planet. Large resources totaling over Rs 2,900 crore were allocated under the 10th Plan for the tourism sector. The hotel industry was given the status of infrastructure.

The emphasis of the central government would be to open up the eco-tourism business-trekking and wild life, besides continuation of heritage and monuments related tourism.

3.5.7 Education

'Smart Goals' with a future vision 'Education for All' is a major Project of the Education Department with its Continuous Education and Literacy Policies geared to promote Literacy, reduce dropout rates, Focus on Girl Education, Teachers Training and a series of other Initiatives being implemented.

Girl Education, Infrastructure, Health and Sanitation are the many areas in the process of continuous Education, Literacy, and Education awareness and on path to enhancement in quality implementation. The Government vision is for SEE (Socio-Economic-Education) growth with primary education, secondary education, higher education, continuous education, literacy education, technical education, pharmacy education etc.

3.5.8 Transportation

Gujarat's towns and cities are well connected to each other and to the rest of India-by road and rail. Coastal shipping routes link the state's many ports. Kandla is a major international shipping terminal. There is air service both within the state and to major Indian cities outside Gujarat.

3.5.9 Health

Gujarat State has an expensive network of health and medical service institutions. To meet primary health care needs, it has 911 Primary centers, 7284 Sub Centers and 161 Community Health Centers to meet emergency referred needs.

Department of Health & Family Welfare, Government of Gujarat has created wide network of health and medical care facilities in the state to provides primary, secondary and tertiary health care at the door step of every citizen of Gujarat with prime focus on BPL families, marginalized population and weaker sections in rural and urban slum areas. Department also takes appropriate actions to create adequate educational facilities for medical and paramedical manpower in the state of Gujarat. Government of Gujarat is committed to provide medical facilities at the most level, keeping pace with rapid technological developments in the field of Healthcare.

3.5.10 Drinking Water

Gujarat is a water stressed state, with its per capita availability of fresh water at 1137 m³ (less than 1700 m³ per year). Several region of the state even suffer from chronic water shortages. This shortage is reflected in the shortage of potable water in many parts of the state, particularly in North Gujarat, Saurashtra and Kachachh.

The main source of water for Gujarat is surface water. The State has 185 river basins and the available quota of water in the State is 55608 million cubic meters, out of which, 38100 million cubic meters is surface water, which is only 2% of the entire quota of surface water of the country. Moreover, the available quota of surface water is also not distributed properly. Gujarat, Saurashtra and Kutch have water resources of 89%, 9% and 2% respectively, against this; the total geographical area of these regions is 45%, 31% and 24% respectively. The underground water resources of State are 17508 million cubic meters.

The quota of available surface and underground water is used for drinking purpose, industries, agriculture and hydal power, fisheries etc. Out of which, nearly 80% quota is used for agricultural production, in which irrigation also plays an important role.

3.5.11 Infrastructure in Rajkot District

3.5.11.1 Economy and Industry

Rajkot has a strong manufacturing economic base, with a market that extends not only beyond the state of Gujarat, but even the national boundaries. In its early history Rajkot was organized around the establishment of cloth mills. More recently, the emphasis has shifted to small and medium industries dominated by foundries, manufacture of oil engine, machine tools, engineering and automobile works, castor oil processing, gold and silver jewelers, handicrafts, readymade ladies garment, spices, medicines and wall clocks. Manufacturing activities are concentrated in two main industrial estates namely, Aji industrial estate and Bhaktinagar industrial estate; in addition, many small units are scattered through the city.

The occupational pattern in Rajkot is primarily based on manufacturing and service sector. About 42% of workers are engaged in service activities and 34% in manufacturing activities.

3.5.11.2 Transport

Transportation is the backbone to the development of urban areas. It enables functioning of urban areas efficiently by providing access and mobility. Passenger transport has an overriding influence on the functioning of the city. Traffic, Transportation service and Road network are key indicators to provide the image of city. The city has a dense road network. Because of the concentration of various commercial and industrial activities in Rajkot and surrounding towns, the city road network leading to the surrounding towns is heavily congested. The regional network includes NH-8B, State Highways (SH-26, SH-27 & SH-42) and District Roads. The influence area, in terms of travel demand, covers the revenue districts of Rajkot. There is heavy inflow of traffic from the region into the city and vice-versa. The Jamnagar, Gondal and Viramgaon railway lines pass through middle of Rajkot City.

The city is connected with other parts of the country by Rail, Road and Air. There are two railway stations, one at Junction Plot area and another at Bhaktinagar. There are broad gauge railway line of Western Railway between Viramgam-Okha-Porbandar and meter gauge railway line between Jetalsar-Veraval-Bhavanagar. It is also well connected by broad gauge railway line with Delhi and Bombay the important two Metropolitan cities of India. There is an airport in Rajkot and the major domestic airlines run flights between Rajkot and Mumbai. Indian Airlines has four flights a week to Mumbai while Jet and Sahara have daily flights.

3.5.11.3 Education

Saurashtra University is a major university. The university is well known for several schools including private, government granted schools. Primary Schools 1845, Secondary Schools 426, and Higher Secondary are 40. There are 5 Engineering colleges in the district, ITIs 17 offering courses and 7 Polytechnic.

3.5.11.4 Health

Rajkot has 50 primary healthcare centers, 13 Community healthcare centers, 3 Civil Hospitals and 12 Government Hospitals.

3.5.11.5 Tourism

The main tourist attractions in Rajkot are the Mahatma Gandhi House or Karba Gandhi No Delo, Watson museum, Aji Dam, Jagat Mandir, Rajkumar College, Lang Library, Lal Pari Lake and Randerda. The Karba Gandhi No Delo is the house of the Mahatma Gandhi where he lived from the age of six. The Mahatma Gandhi House has a good collection of things related to the Mahatma Gandhi's life. The Mahatma's Passion for the handloom is preserved in the form of a small weaving school. Lal Pari Lake and Randerda is a picturesque picnic spot, situated about 5 km from Rajkot. Aji Dam is situated about 8 km from Rajkot and supplies the town's water. Rashtriya Shala was founded by Mahatma Gandhi which has a center of patola weaving. The Lang Library has a collection of thousands of documents and books covering every period in Rajkot and Saurashtra (region) history.

3.5.12 Infrastructure in Jamnagar District

3.5.12.1 Economy and Industry

Jamnagar city has a burgeoning economy and its economic development may be attributed to the many prosperous business, trades and Industries that have their base in the city and really functioning as a major economic backbone for the city. Providing employment to a really large number of people settled there.

Jamnagar is known as 'World's Oil City' because the world's biggest oil refinery, belonging to Reliance Industries, and a smaller one belonging to Essar Oil are located in Jamnagar. It was formerly known as 'Brass City', since it houses more than 5,000 large-scale and 10,000 small-scale workshops manufacturing brass items in and around the industrial estates of Shankar Tekari, Udhyognagar, M P Shah Udhyognagar and Dared.

Jamnagar has base stations of all three wings of Defence: the Indian Air Force, Indian Army, and Indian Navy. Geographically Jamnagar supports all branches of defiance, as it has access to the sea for the Indian Navy and a large air base due to the city's strategic location close to Pakistan. The city has an all-weather intermediate seaport

3.5.12.2 Transport

The district is well connected with the State capital and surrounding district headquarters through road and rail linkages. The road network consists of National Highways, State Highways and Major District Roads. The rail network consists of both broad gauge as well as single track lines. The district headquarter has connectivity through airways for transport and trade to major airports within the country and to select international destinations. The city

has an airport (IATA: JGA – ICAO: VAJM) with direct flights to Mumbai. The airport is a civil enclave which allows commercial flights.

3.5.12.3 Education

Jamnagar has many schools including private, government granted schools. Primary Schools 1316, Secondary Schools 156, and Higher Secondary are 45. The M.P. Shah Medical College is considered to be one of the top colleges in India for Medical studies. The Gujarat Ayurveda University in Jamnagar is considered to be the best university in the world for Ayurveda studies & has students from all around the globe. Besides this, there are several colleges for arts, commerce and science.

3.5.12.4 Health

The district has 36 primary healthcare centers and 11 community healthcare centers Apollo Group of Hospitals has its telemedicine center linked at a hospital in Jamnagar The Ayurveda University in the district hosts a renowned 36 Ayurveda center equipped with state -of-the-art-techniques and provide a whole range of Ayurveda treatments.

3.5.12.5 Tourism

Jamnagar the Jewel of Kathiawar, is on the coast of Gulf of Kutch in the state of Gujarat, India. It has un spoilt Islands & Beaches, Hills, Temples, Palaces, Forest, Fantastic Bird life in the Bird Sanctuary & Marine Sanctuaries and Fascinating Corals One can visit the:

- City Lake full of 75 varieties of Birds.
- Islands full of sea shells, corals, birds, octopus.
- Un spoilt Beaches, both white and golden sands.
- Hills with temples on top.
- Forest with leopards, jackals, wolves, jungle cat, blue bulls, hyena, snakes.
- Temples ranging from the ancient to the new also includes a Guinness World Record holder.
- Bird Sanctuaries with 250 varieties of birds.
- Marine Sanctuaries with dolphins, octopus, turtles, dugong, fish.
- Marine National Park and Marine Life in the Marine National Park.

3.6 TOURSIM IN GUJARAT STATE

Gujarat is the 6th largest state in India, located in the western part of India with a coastline of 1600 km (longest in India). It is one of the most popular tourist regions in the country, and was visited by 19.8 million domestic and international tourists in 2010-11. Gujarat offers

scenic beauty from Great Rann of Kutch to the hills of Saputara. Gujarat is the one and only place to view pure Asiatic lions in the world. During the Sultanate reign, Hindu craftsmanship mixed with Islamic architecture, giving rise to the Indo-Saracenic style. Many structures in the state are built in this fashion.

It is also the birthplace of Mahatma Gandhi and Sardar Vallabhbhai Patel, iconic figures of India's independence movement. Amitabh Bachchan is currently the brand ambassador of Gujarat Tourism. The 'Khushboo Gujarat Ki' campaign by celebrity Amitabh Bachchan has increased tourism in Gujarat by 4 per cent per annum, twice that of national growth rate.



Majestic Laxmi Vilas Palace (Built By Maharaja Sayajirao Gaekwad III), Baroda



Mahatma Gandhi's Visitor Room at Hridaya Kunj



Asiatic Lion at Gir

3.6.1 Business tourism

Gujarat is one of the most industrialized states in the country. There are many Indian and global companies located in Gujarat and the area has seen double digit GDP growth in past decade. It is also known as “Growth Engine of India”.

Vibrant Gujarat is biennial investors' summit held by the government of Gujarat. The event is aimed at bringing together business leaders, investors, corporations, thought leaders, policy and opinion makers; the summit is advertised as a platform to understand and explore business opportunities in the state. It has become a model for economic success for many states. According to the list of the top 10 Indian cities by GDP in 2009, based on a Price water house Coopers study, Ahmadabad ranks 7th in India with an annual GDP of 59 billion USD.

3.6.2 Archaeological and heritage tourism

Gujarat there is a wide variety of historic forts, palaces, mosques, temples, and places of historical importance in India's struggle for independence. Many of this palaces and forts have been converted into heritage hotels to keep tourists close to the vibrant history of Gujarat.

3.6.3 Religious tourism

Gujarat- Home to multitude devotional centers and temples with Famous Religious Centers like Dwarka, Dakor, Ambaji, Palitana, Mahudi, Shankheshwar, Somnath, Shamlaji, Bahucharaji, Pavagadh, Kabirvad, Sun Temple, Modhera, Akshardham (Gandhinagar), Shri Swaminarayan Mandir, Ahmedabad, Jain temples, Hindu Temples and Sudama Mandir, Ashapura mataji madh- Kutch, Swaminarayan Mandir - Bhuj, Narayan Sarovar, Tulsi Shyam, Sattadhar, Lojpur, Junagadh Buddhist Cave Groups etc.

3.6.4 Cultural tourism

Gujarat is well known for its rich culture. The folk arts of Gujarat form a major part of the culture of the state. It preserves the rich tradition of song, dance, drama as well. Handicrafts include Bandhani, patolas of Patan, kutchhi work, Khadi, bamboo craft, block printing, embroidery, woodcraft, metal crafts, pottery, namda, rogan painting, pithora and many more handicrafts.



A Meghwal woman in the Hodka village,
North of Bhuj



Women and men performing Garba as part
of Navaratri celebrations in Ahmedabad

3.6.5 Wildlife tourism

Gujarat is habitat for the world's rarest as well large number of Fauna & Flora, Fauna includes Asiatic Lions, Wild Ass, Blackbuck, Bears, Monkeys, Nilgai, Paradise Flycatcher, Chinkara, Dolphins, Whale Shark and Migratory Birds like Flamingos, Pelican, Storks. Flora includes species of Khair, Sadad, Timru, Babul, Salai, Khakro, Ber, Asundro and Bordi. The state also has National park. Tourism Department along with Forest department of Gujarat are maintaining many campsites to promote Eco-tourism in Gujarat.

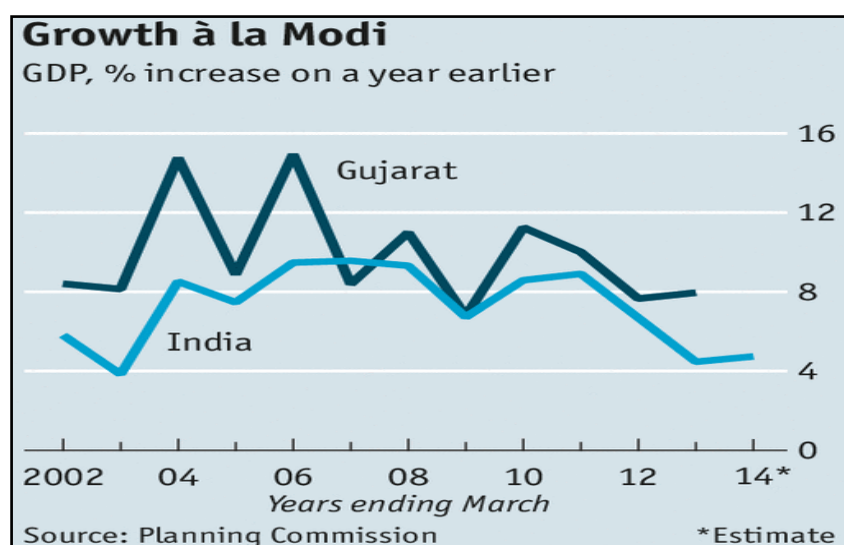
3.6.6 Medical tourism

Ahmadabad leading city of the state is the most preferred place for medical tour or medical treatments in India. With world class health facilities and affordable cost, the city is becoming one of the most sought medical tourism center in the country. The 108 Service is the highly appreciated 'Medical at doorstep' Service. More than 1500 foreigners visit the state per year for various treatments in the state. Ahmadabad Civil Hospital is the biggest hospital in Asia located at Ahmadabad. There are many new upcoming hospitals coming in the city too.

3.7 GDP IN GUJARAT STATE

The State is among the top five major State economies and it contributes about 7.32 percent to the GDP at National level during the year 2011-12, through the states share to India's population is about 4.99 percent.

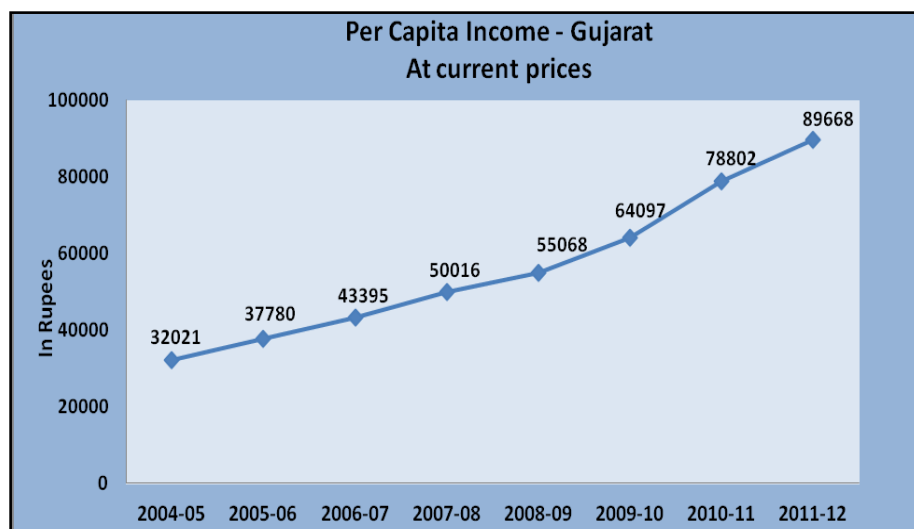
For the Eleventh Five Year plan, a very high growth target of 11.2 percent has been set for Gujarat State by Planning commission Government of India. The State economy has been measured in terms of the Gross State Domestic Product (GSDP) at factor cost at constant prices as well as at Current prices. **Figure 3.6** shows GDP % Increase on a year earlier



Source: Planning Commission

Figure 3.6: GDP % Increase on a Year Earlier

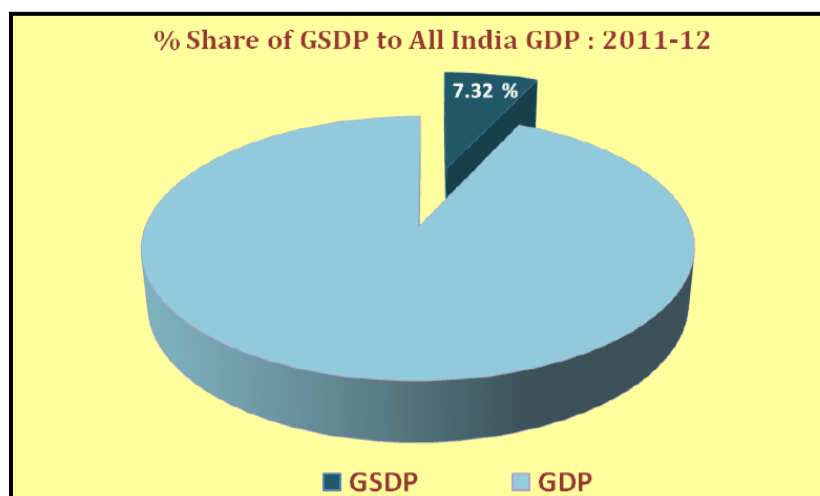
The Per Capita Income (i.e. per capita NSDP at factor cost) at Constant (2004-05) Prices has been estimated at Rs.57508 in 2011-12 as against Rs. 53789 in 2010-2011, registering a growth of 6.9 percent during the year. The Per Capita Income at current prices has been estimated at Rs. 89668 in 2011-12 as against Rs. 78802 in 2010-11, showing an increase of 13.8 percent during the year. **Figure: 3.7 shows per Capita Income (In Rs.)**



Source: Directorate of Economics and Statistics Government of Gujarat

Figure 3.7: Per Capita Income (In Rs.)

The share of primary, secondary and tertiary sectors has been reported at 17.9 percent, 35.1 percent and 47.0 percent respectively to the total GSDP (Rs. 670016 core) in 2012-13 at current prices. The Per Capita Net National Product Rs. 54835 at current price and Rs.35917 at constant price (2004-2005) for the year 2010-11. The pattern of increase in per capita Net National Product during to 2004-2011 is presented in the **Figure 3.8.**



Source; State Domestic Product State 2011-12

Figure 3.8: Per Capita Net National Income

The Gross State Domestic Product (GSDP) at factor cost at constant (2004-05) prices in 2012-13 has been estimated at Rs. 427219 crore as against Rs. 395738 core in 2011-12 registering a growth of 8.0 percent during the year. Gross State Domestic Product at factor cost at current prices in 2012-13 has been estimated at Rs. 670016 core as against Rs. 594563 crore in 2011-12, registering a growth of 12.7 percent during the year. **Table 3.4** shows Gross State Domestic product:

Table 3.4: Gross State Products (Rs. In core)

S. No.	Year	Current Prices	% age growth over previous year	Constant (2004-05) prices	% age growth over previous years
1	2004-05	203373	-	203373	-
2	2007-08	329285	16.1	281273	11.0
3	2008-09	367912	11.7	300341	6.8
4	2009-10	431262	17.2	334127	11.2
5	2010-2011(P)	521519	20.9	367581	10.0
6	2011-12 (P)	594563	14.4	395738	7.7
7	2012-13(Q)	670016	12.7	427219	8.0

(P) = Provisional, (Q)= Quick estimate

Source: Economic review; Gujarat State, 2013-14

3.7.1 Sectoral Composition of the State Income

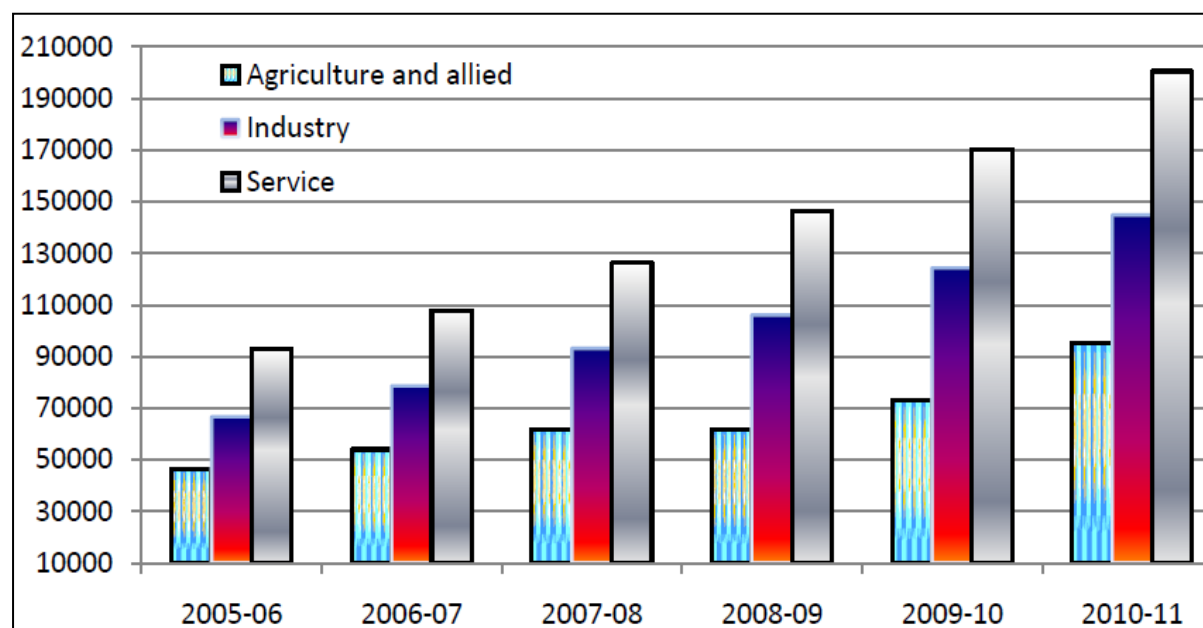
Since 1960-61, there has been a significant structural shift in the State economy. Like other developing economies, there is a gradual increase in share of Industry and Services sectors and thereby decline of share in primary sectors. At current prices, in 1960-61, the share of primary sector was 41.8 per cent which went down to 38.7 percent in 1980-81 and further declined to 18.2 per cent in 2009-10. In 1960-61, the share of secondary sector in economy was 25.7 per cent which increased to 29.0 per cent in 1980-81 and further grew up to 36.9 per cent in 2009-10 indicating that the secondary sector has gained momentum after the year 1980-81. Whereas, the share of tertiary sector in economy was 32.5 per cent in 1960-61 which remained stable in 1980-81 at 32.3 per cent and thereafter gained a steep rise and registered a share of 44.9 per cent in 2009-10. The sectoral contribution by broad sectors i.e primary, secondary and tertiary sectors at current and at constant (2004-05) prices is given below in **Table 3.5**.

Table 3.5: GSDP Sectoral Contribution by Broad Sectors (Percent)

S. No.	Industry	At Current Prices			At 2004-05 Prices	
		2004-05	2008-09	2009-10	2008-09	2009-10
1	Primary	19.5	18.2	18.2	15.6	14.2
1.1	Agriculture	13.2	13.6	13.8	11.2	10.2
2	Secondary	36.5	37.7	36.9	37.5	38.6
2.1	Manufacturing	27.5	27.6	26.4	27.2	27.4
3	Tertiary	44.0	44.1	44.9	46.9	47.2

Source: Directorate of Economics and Statistics Government of Gujarat

The share of primary, secondary and tertiary sectors has been reported to be 18.2 per cent, 36.9 per cent and 44.9 per cent respectively to the GSDP (Rs. 429356 crore) in 2009-10 at current prices. **Figure 3.9** Sectoral Composition of NSDP at Current Price in Gujarat (2005-06 to 2010-11) shown below.



Source: State of Gujarat Agriculture 2011-12

Figure 3.9: Sectoral Composition of NSDP at Current Price in Gujarat

3.8 JUSTIFICATION OF PROJECT IMPACTS AND BENEFITS

To enhance project benefits for roadside communities and road users, the project design has incorporated the following: The possible direct and indirect positive impacts are listed below.

The proposed project can be viewed as boosting economic growth and poverty reduction which will bring substantial social and economic development in the region. The implementation of this project envisages the following direct benefits:

- (I) Improved quality of life for the rural as well as urban population in the project area which will result in:
- Improving performance of road network for enabling traffic to move safely, Expeditiously, Economically and comfortably,
 - Improve road connectivity across Row for stimulating growth, better access for interstate traffic and other facilities,
 - Stimulating for local economic activity,
 - A more efficient and safe road transport system, through reduced road accidents, reduced vehicle operating and maintenance costs and reduced transportation cost for goods,
 - The improved road will reduce travel times, fuel consumption and emission from base traffic volumes,
 - Drainage/ erosion will be considerably improved because of the provision of improved side drains,
- (II) Improved road surface will give a satisfactory service throughout the year, with the implementation of the project; following benefits apart from the benefits targeted through the objectives are envisaged.
- Short term employment opportunities due to construction activities and development of diversified skill set for local labours,
 - Improved economic development of corridor villages,
 - Improvement in the drainage conditions along the corridors due to improved design and construction of cross drainage structures,
 - Improved safety of road users and roadside communities.

Although various positive impacts and benefits are expected from the proposed project as mentioned above, there will be some negative impacts on title holders and non-title holders such as encroachers and squatters who are living near the immediate corridor of impacts in terms of loss structures, and fresh private land acquisition. The project proposal has been made considering criteria of minimum negative social impacts.



CHAPTER - 4

TRAFFIC SURVEY AND ANALYSIS

CHAPTER - 4

TRAFFIC SURVEY AND ANALYSIS

4.1 INTRODUCTION

Traffic surveys are a fundamental constituent of a comprehensive traffic and transportation study. Assessment of existing traffic and travel characteristics is extremely important for developing a precise traffic and transportation plan.

The project corridor is located in the State of Gujarat. It passes through Jamnagar district. The corridor under study, part of SH-26, is declared as NH-927D. This project envisages that “Consultancy Services for Project Management Phase-I including preparation of Detailed Project Report for up gradation of Junction with NH-27 near Dhoraji-Jamkandorna, Kalavad-Jamnagar section of NH-927D in the state of Gujarat to four lane with paved shoulder configuration”.

This chapter includes all the required details of traffic surveys conducted, analysis performed and forecasts made which are presented in following Sections.

4.2 PLANNING OF TRAFFIC SURVEY

4.2.1 Planning of Surveys

Traffic survey stations for carrying out various traffic surveys such as Traffic Volume Count, Axle Load Survey, and Origin-Destination survey were conducted considering the following parameters:

- The location of stations represents the traffic homogeneous sections.
- The locations identified based on the network study.

4.2.2 Schedule of Primary Surveys

To capture traffic flow characteristics and travel pattern of users passing through the project road, the following primary traffic surveys were conducted.

- Classified Traffic Volume Count Survey (CVC)
- Origin-Destination Survey (OD)
- Axle Load Survey (AXL)

The traffic survey locations are presented in **Table 4.1**.

Table 4.1: Traffic Survey Locations

S. No.	Traffic Survey Type	Locations (New)		Locations (Old)	
		Existing km Chainage	Effective Date & Duration	Existing km Chainage	Effective Date & Duration
1	CVC-01	Km 9+430 (Ch 41.833 Between Jamnagar & Kalavad) Proposed Toll Plaza location near Mota Thavariya Village	23.12.2024 to 30.12.2024 (7Days)	Km 10+000 Near Vijarkhi	05-07-2015 to 12-07-2015 (7Days)
2	OD-01	Km 9+430 (near Mota Thavariya Village)	26.12.2024 to 27.12.2024 (24 hrs.)	Km 10+000 Near Vijarkhi	08-07-2015 to 09-07-2015 (24 hrs.)
3	AXL-01	Km 9+430 (near Mota Thavariya Village)	26.12.2024 to 27.12.2024 (24 hrs.)	Km 10+000 Near Vijarkhi	07-07-2015 to 08-07-2015 2 Days (12 hrs.)
4	CVC-02	Km 52+200 (Between Dhoraji & Kalavad) Near Shining Star School	23.12.2024 to 30.12.2024 (7Days)	-	-



Figure 4.1: Traffic Survey Locations

4.2.3 Survey Methodology and Conduct of Surveys

4.2.3.1 Classified Traffic Volume Counts

The classified Traffic Volume Count (CVC) Survey was conducted with Video count at two locations along the Dhoraji to Jamnagar NH-927D existing alignment, which represents mid-block count stations for the entire homogeneous section of the project road. The count was conducted in both directions for successive 15 minutes periods, 24 hours a day for 7 consecutive days. For carrying out the counts, the vehicles were grouped under the following categories as shown in **Table 4.2**.

Table 4.2: Vehicle Classification System

Motorized Vehicles		Non-motorized Vehicles
2 wheelers		Bicycle
3 wheelers		Cycle Rickshaw
Passenger Car	Car, Jeep, Taxi & Van	Hand Cart
Bus	Mini Bus	Animal Drawn
	Standard Bus	
LCV	4–Tyre & 6–Tyre	
Truck	2 – Axle Truck	
	3 – Axle Truck	
	MAV (4 to 6 Axle)	
	OSV (7 Axle & above)	
Agricultural Tractor (With & Without Trailer)		

4.2.3.2 Origin-Destination Survey

The Origin-Destination survey was carried out with the primary objective of studying the travel pattern of goods and passenger traffic along the NH-927D. The results have also been useful for identifying the influence of connecting roads over the project road, and also for estimating the growth rates of traffic and diversion of traffic on the project road.

The O-D survey was carried out for one day (24 hours) at one location (shown in **Table 4.1**) simultaneously along with the classified traffic volume counts. Roadside interview method was adopted for the survey. The vehicles were stopped on random sample basis with the help of police, and trained enumerators interviewed the drivers to obtain the required data. During the surveys the information pertaining to trip length, commodity types, loading pattern and trip purpose as applicable for various vehicle types were recorded. The vehicle types are given in **Table 4.2**.

4.2.3.3 Axle Load Survey

Axle Load Survey was carried out at one location on the project road. The main purpose for carrying out the survey was to assess the overloading pattern on the corridor and to estimate Vehicle Damage Factor based on the commercial (Heavy) vehicle volume which is using the road.

During the survey, Axle load of commercial vehicles, i.e. LCVs, 2-Axle, 3-Axle, Multi Axle Trucks and Buses, were weighed on random sampling basis. The vehicles were stopped with the help of police and the drivers were directed to stop their vehicles in such a way that wheel of each axle can be weighed using portable Axle Load Weighing Pad. The readings were recorded by trained enumerators for each axle separately and the surveys were carried out for 1 day, 24 Hours.

4.3 TRAFFIC DATA ANALYSIS

Classified traffic volume count surveys were conducted at two locations; km 9+430 and km 52+200 in accordance with IRC: 9-1972. The PCU values adopted are as follows:

Table 4.3: Adopted PCU values for Project section

Fast Vehicles		Slow Vehicles	
Vehicle Group	PCU Factor	Vehicle Group	PCU Factor
Car, Jeep, Van, Taxi and Utility Vehicles	1.0	Bi-cycle	0.5
Auto Rickshaw / Tempo	1.0	Cycle-Rickshaw	2.0
2 Wheelers	0.5	Animal Drawn	6.0
Mini Bus	1.5	Hand Drawn	3.0
Standard Bus	3.0		
Light Commercial Vehicle (LCV)	1.5		
2 – Axle Truck	3.0		
3 – Axle Truck	3.0		
Multi Axle Truck (4 and above)/ HCM/EME	4.5		
Agriculture Tractor	1.5		
Agriculture Tractor with Trailer	4.5		

The counts observed have been analyzed for the following:

- Average Daily Traffic (ADT)
- Traffic Composition

- Daily Variation of Traffic
- Hourly Variation of Traffic
- Directional Distribution
- Annual Average Daily Traffic (AADT)

4.3.1 Average Daily Traffic

The average value of Traffic Volume Count Data for 7 days count at two locations has been calculated to determine the Average Daily Traffic (ADT). The Average Daily Traffic (ADT) in terms of Vehicles and PCU for both directions traffic is shown in Tables given below:

Table 4.4: Average Daily Traffic (ADT) CVC-1 at km 9+430

Categories	UP				DN				Both Directions			
	As per 2024 Survey		As per 2015 Survey		As per 2024 Survey		As per 2015 Survey		As per 2024 Survey		As per 2015 Survey	
	Vehicles	PCU	Vehicles	PCU	Vehicles	PCU	Vehicles	PCU	Vehicles	PCU	Vehicles	PCU
2-Wheeler	2,476	1,238	2,116	1,058	2,539	1,270	1,982	991	5,015	2,508	4,098	2,049
3-Wheeler	285	285	313	313	286	286	304	304	571	571	617	617
Car	1,557	1,557	907	907	1,625	1,625	813	813	3,182	3,182	1,720	1,720
Mini LCV	259	259	174	174	267	267	207	207	526	526	381	381
Mini Bus	4	6	18	27	4	6	26	39	8	12	44	66
Standard Bus	99	149	118	354	91	137	109	327	190	286	227	681
LCV - 4 Tyre	0	0	27	41	0	0	40	60	0	0	67	101
LCV - 6 Tyre	177	266	78	117	166	249	100	150	343	515	178	267
2-Axle	216	648	201	603	201	603	178	534	417	1,251	379	1,137
3-Axle	73	219	260	780	75	225	175	525	148	444	435	1,305
MAV (4 to 6)	97	437	201	905	96	432	98	441	193	869	299	1,346
OSV (7++ Axle)	0	0	5	23	0	0	5	23	0	0	10	46
HCM/EME	3	14	6	27	4	18	8	36	7	32	14	63
Tractors With Trailer	49	221	64	288	46	207	65	293	95	428	129	581
Tractors Without Trailer	8	12	10	15	9	14	13	20	17	26	23	35
Bi-Cycle	2	1	25	13	3	2	21	11	5	3	46	24
Cycle-Rickshaw	0	0	1	2	0	0	0	0	0	0	1	2

Categories	UP				DN				Both Directions			
	As per 2024 Survey		As per 2015 Survey		As per 2024 Survey		As per 2015 Survey		As per 2024 Survey		As per 2015 Survey	
	Vehicles	PCU	Vehicles	PCU	Vehicles	PCU	Vehicles	PCU	Vehicles	PCU	Vehicles	PCU
Animal-Drawn	0	0	5	30	0	0	9	54	0	0	14	84
Hand-Drawn	0	0	1	3	0	0	0	0	0	0	1	3
Exempted Vehicle	56	56	14	14	57	57	15	15	113	113	29	29
Total Slow-Moving Vehicles	2	1	32	48	3	2	30	65	5	3	62	113
Total Fast-Moving Vehicle	5,359	5,367	4,512	5,646	5,466	5,396	4,138	4,778	10,825	10,763	8,650	10,424
Total Commercial Traffic	669	1,739	914	2,877	637	1,670	739	2,135	1,306	3,409	1,653	5,012
Total Tollable Traffic	2,485	3,555	1,995	3,958	2,529	3,562	1,759	3,155	5,014	7,117	3,754	7,113
Total Traffic	5,361	5,368	4,544	5,694	5,469	5,398	4,168	4,843	10,830	10,766	8,712	10,537

The above table provides data and comparison of the total traffic for the road segment CVC-1 conducted at km 9+430 on year 2024 and CVC-1 at km 10+000 on year 2015.

At km 9+430, the UP direction, the total number of vehicles is 5,361, while in the DOWN direction, it is 5,469 resulting in a combined total of 10,830 vehicles. For the PCU (Passenger Car Unit) values, the UP direction has 5,368 PCU, and the DOWN direction has 5,398 PCU, leading to a total of 10,766 PCU.

At km 10+000, The total number of vehicles found that 8,712 and total of 10,537 PCU. As we compare with present traffic, the total number of vehicles increased to 2,118 Vehicles and PCU's are more or less same.

Table 4.5: Average Daily Traffic (ADT) CVC-2 at km 52+200

Categories	CVC-2 km 52+200					
	UP		DN		Both Directions	
	Vehicles	PCU	Vehicles	PCU	Vehicles	PCU
2-Wheeler	1,028	514	1,024	512	2,052	1,026
3-Wheeler	159	159	146	146	305	305
Car	1,046	1,046	1,036	1,036	2,082	2,082
Mini LCV	148	148	125	125	273	273
Mini Bus	5	8	6	9	11	17
Standard Bus	69	104	61	92	130	196
LCV - 4 Tyre	0	0	0	0	0	0
LCV - 6 Tyre	44	66	42	63	86	129
2-Axle	93	279	92	276	185	555
3-Axle	47	141	43	129	90	270
MAV (4 to 6)	48	216	56	252	104	468
OSV (7++ Axle)	0	0	0	0	0	0
HCM/EME	1	5	0	0	1	5
Tractors With Trailer	32	144	36	162	68	306
Tractors Without Trailer	1	2	1	2	2	4
Bi-Cycle	2	1	2	1	4	2
Cycle-Rickshaw	0	0	0	0	0	0
Animal-Drawn	0	0	0	0	0	0
Hand-Drawn	0	0	0	0	0	0

Categories	CVC-2 km 52+200					
	UP		DN		Both Directions	
	Vehicles	PCU	Vehicles	PCU	Vehicles	PCU
Exempted Vehicle	1	1	1	1	2	2
Total Slow-Moving Vehicles	2	1	2	1	4	2
Total Fast-Moving Vehicle	2,722	2,833	2,669	2,805	5,391	5,638
Total Commercial Traffic	307	819	300	821	607	1,640
Total Tollable Traffic	1,501	2,013	1,461	1,982	2,962	3,995
Total Traffic	2,724	2,834	2,671	2,806	5,395	5,640

The above table provides data on the total traffic for the road segment CVC-2 Dhoraji to Kalavad. In the UP direction, the total number of vehicles is 2,724, while in the DOWN direction, it is 2,671, resulting in a combined total of 5,395 vehicles. the UP direction has **2,834 PCU**, and DN direction has **2,806 PCU**, **total both directional traffic of 5,640 PCU**.

4.3.2 Traffic Composition

The composition of traffic for each survey location in terms of ADT (Nos.) & percentage is as given below:

Table 4.6: Traffic Composition

Categories	CVC-1 at km 9+430 (Ch 41+833)	
	Vehicles	%
2-Wheeler	5015	46.31
3-Wheeler	571	5.27
Car	3182	29.38
Mini LCV	526	4.86
Mini Bus	8	0.07
Standard Bus	190	1.75
LCV - 4 Tyre	0	0.00
LCV - 6 Tyre	343	3.17
2-Axle	417	3.85
3-Axle	148	1.37
MAV (4 to 6)	193	1.78
OSV (7++ Axle)	0	0.00

Categories	CVC-1 at km 9+430 (Ch 41+833)	
	Vehicles	%
HCM/EME	7	0.06
Others	230	2.12
Total Traffic	10,830	100

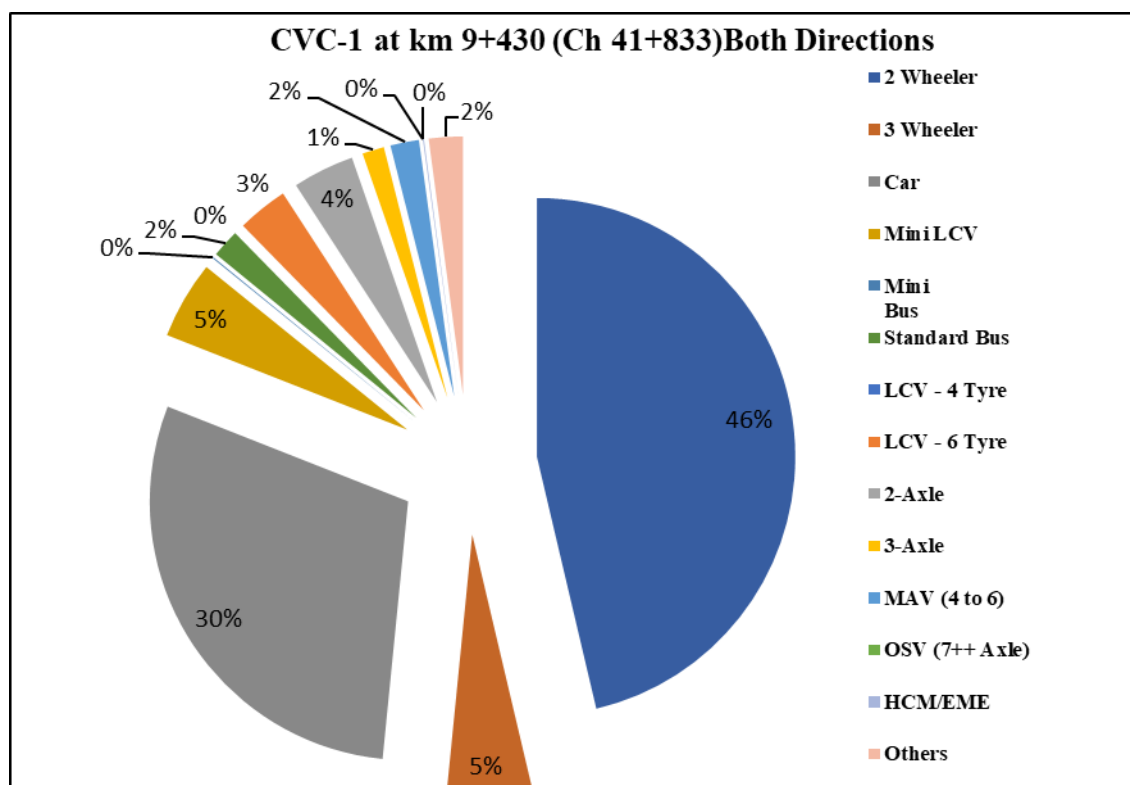


Figure 4.2: Traffic Composition at km 9+430 (Ch 41+833)

From the above data it is understood that on NH-927D, the total traffic consists of 46% two-wheelers, 30% cars, 5% three-wheelers, 5% mini-LCVs, 4% 2-Axle, 3% LCV - 6 Tyre, 2% others, 2% standard buses and the remaining vehicles have very low values, each contributing less than 1%.

Table 4.7: Traffic Composition

Categories	CVC-2 at km 52+200	
	Vehicles	%
2-Wheeler	2052	38.04
3-Wheeler	305	5.65
Car	2082	38.59
Mini LCV	273	5.06

Categories	CVC-2 at km 52+200	
	Vehicles	%
Mini Bus	11	0.20
Standard Bus	130	2.41
LCV - 4 Tyre	0	0.00
LCV - 6 Tyre	86	1.59
2-Axle	185	3.43
3-Axle	90	1.67
MAV (4 to 6)	104	1.93
OSV (7++ Axle)	0	0.00
HCM/EME	1	0.02
Others	76	1.41
Total Traffic	5,395	100.00

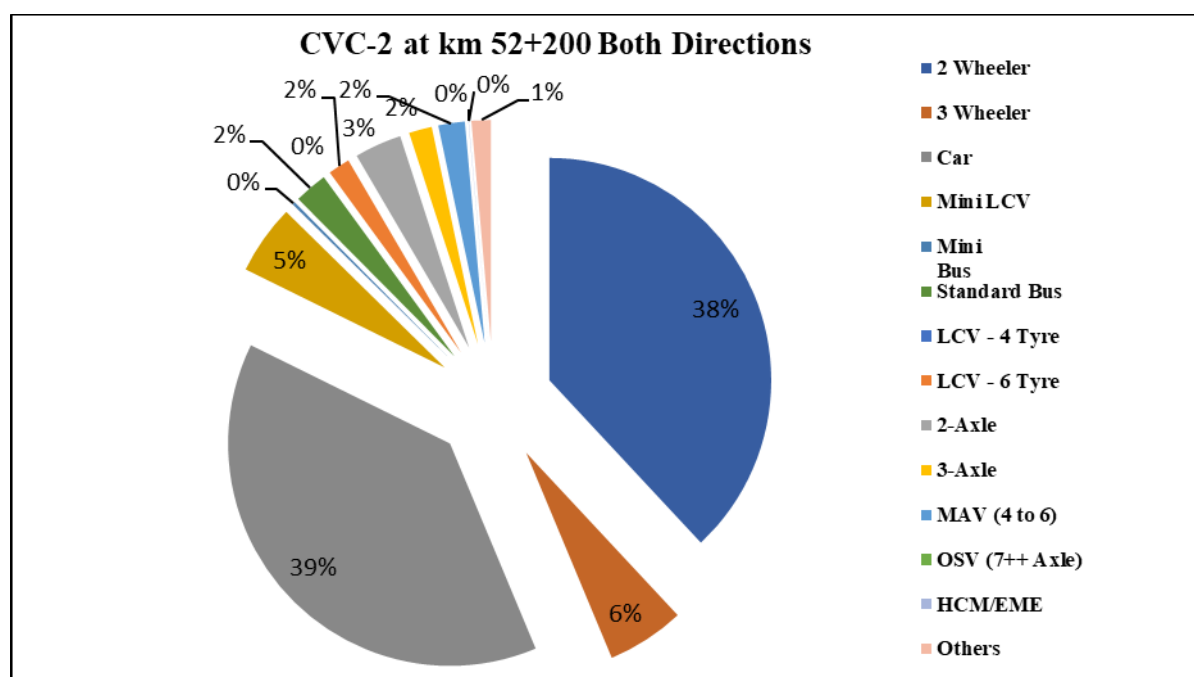


Figure 4.3: Traffic Composition at Km 52+200

From the above data it is understood that on NH-927D, the total traffic consists of 39% cars, 38% two-wheelers, 6% three-wheelers, 5% Mini LCV's, 3% 2-Axle's, 2% standard buses, 2% 3-Axle's, 2% LCV 6 Tyre, 1% others, and the remaining vehicles have very low values, each contributing less than 1%.

4.3.3 Daily Variation

The direction wise daily variation of traffic at two locations wrt 7 days Average follows as:

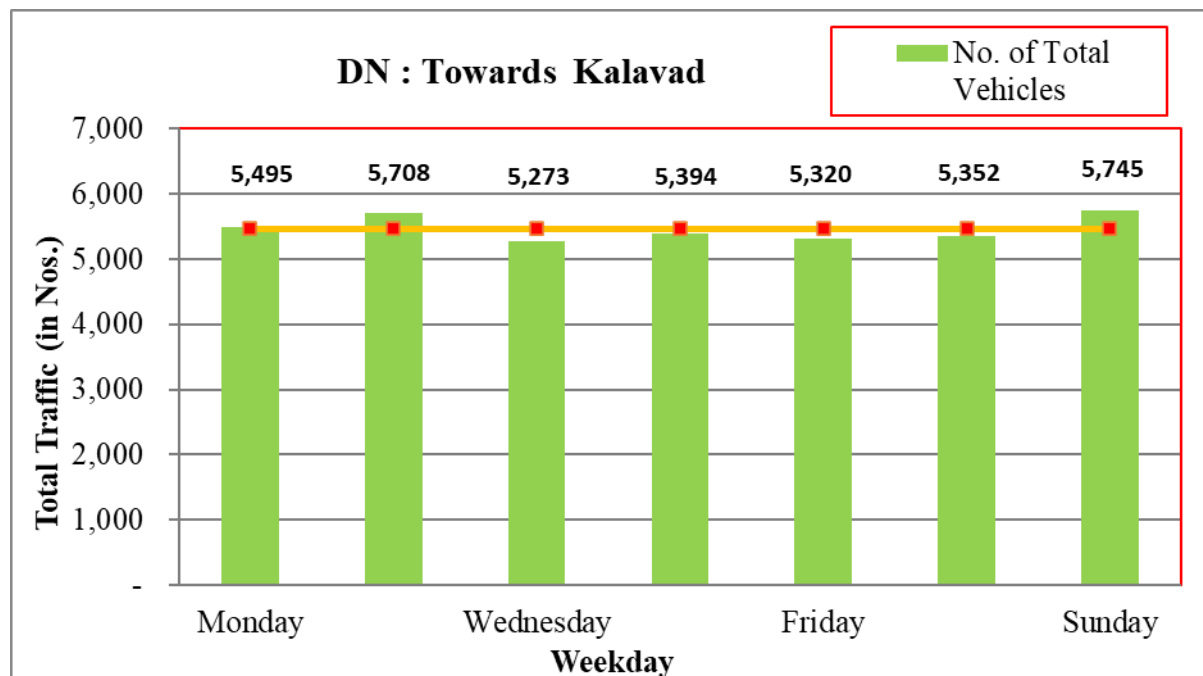


Figure 4.4: Direction wise daily variation of traffic at Km 9+430

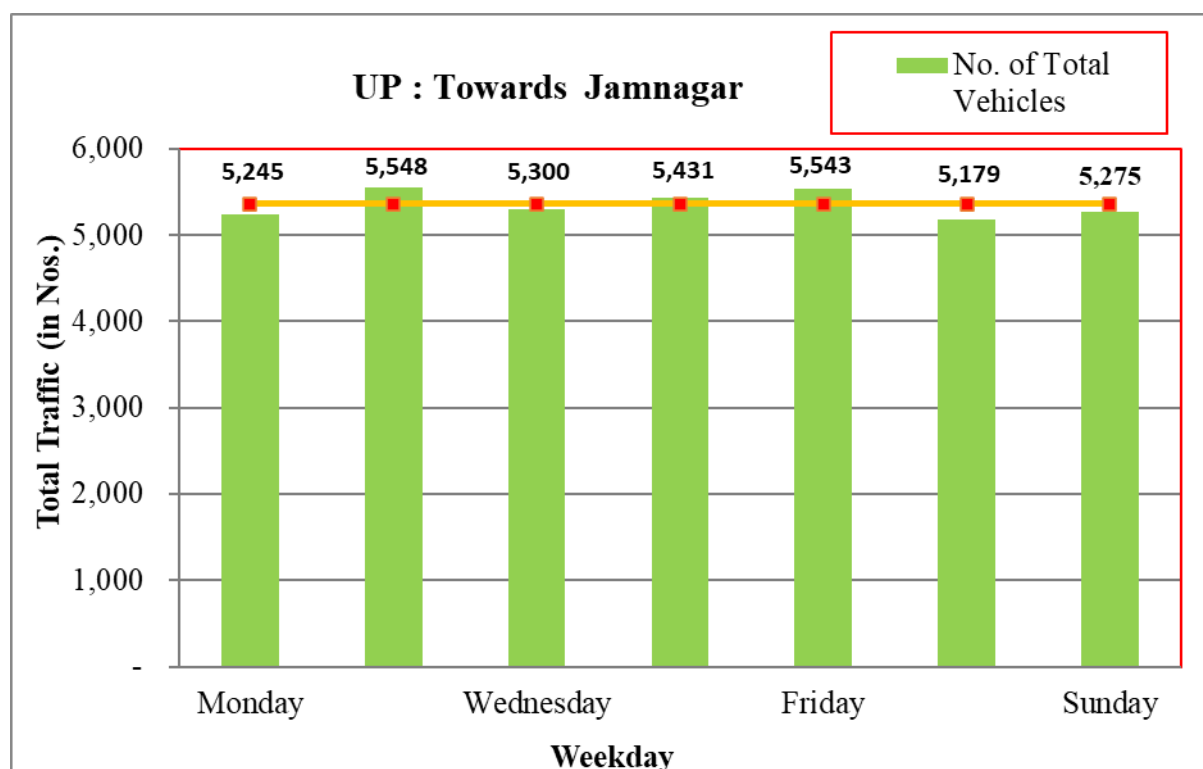


Figure 4.5: Direction wise daily variation of traffic at Km 9+430

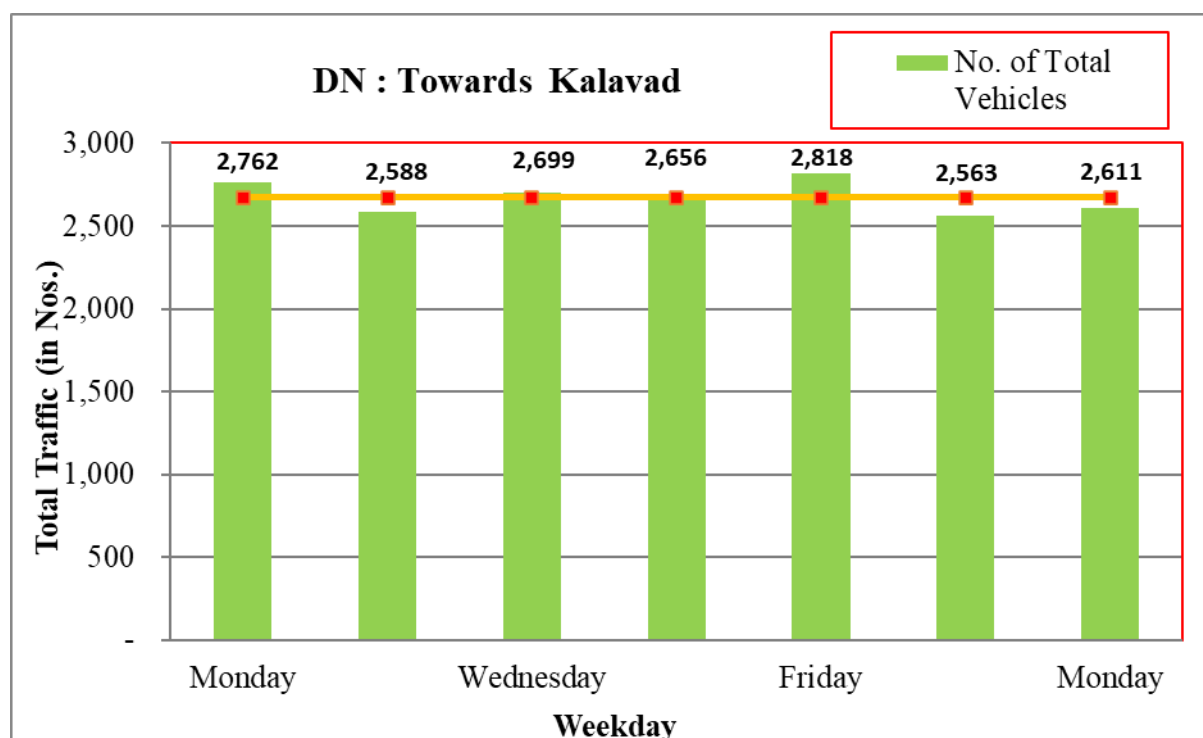


Figure 4.6: Direction wise daily variation of traffic at Km 52+200

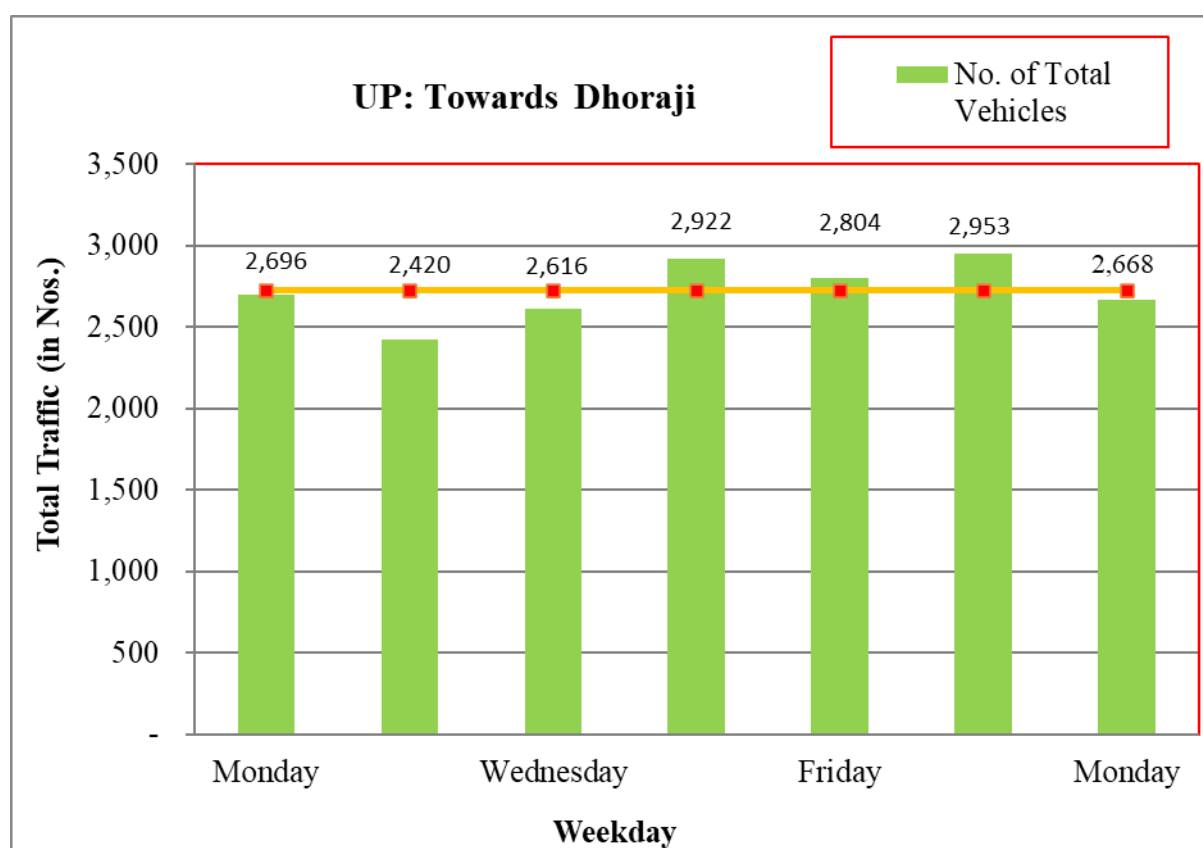


Figure 4.7: Direction wise daily variation of traffic at Km 52+200

4.3.4 Hourly Variation

The hourly variation graphs for the survey location are as follows:

1. CVC-1 at km 9+430 (Ch 41+833)

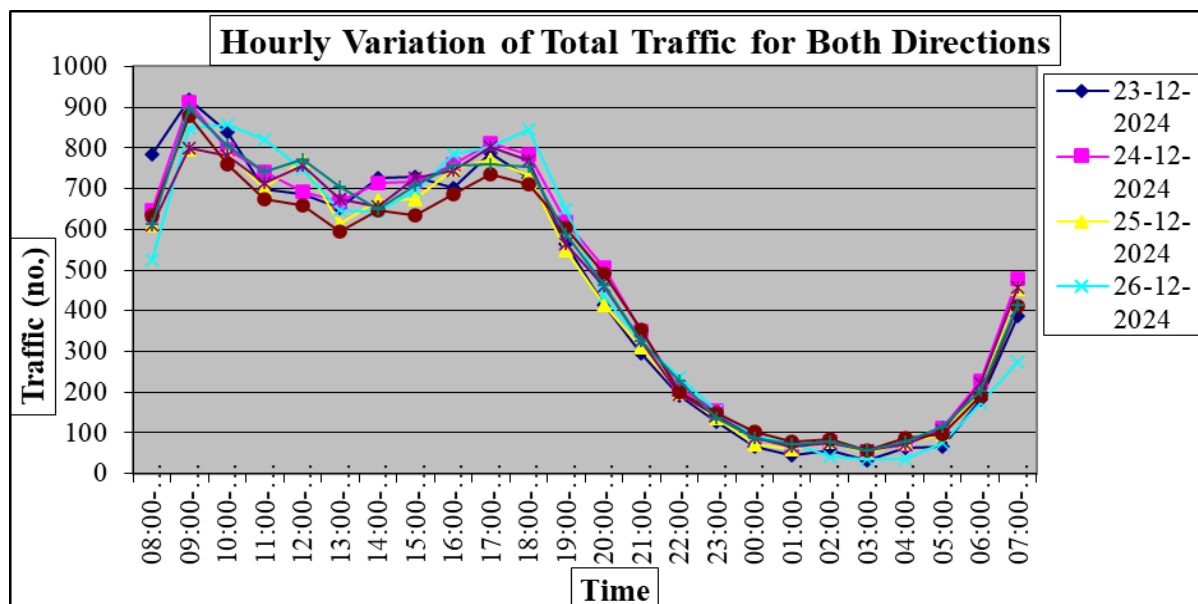


Figure 4.8: Hourly Variation of Total Traffic for Both Directions at km 9+430

It is seen that on NH-927D traffic drops significantly at night between 9 pm to 5 am. This is due to the fact that traffic comprises mainly of passenger vehicles which is dependent upon the movement of the local residents during daylight hours.

2. CVC-2 at km 52+200

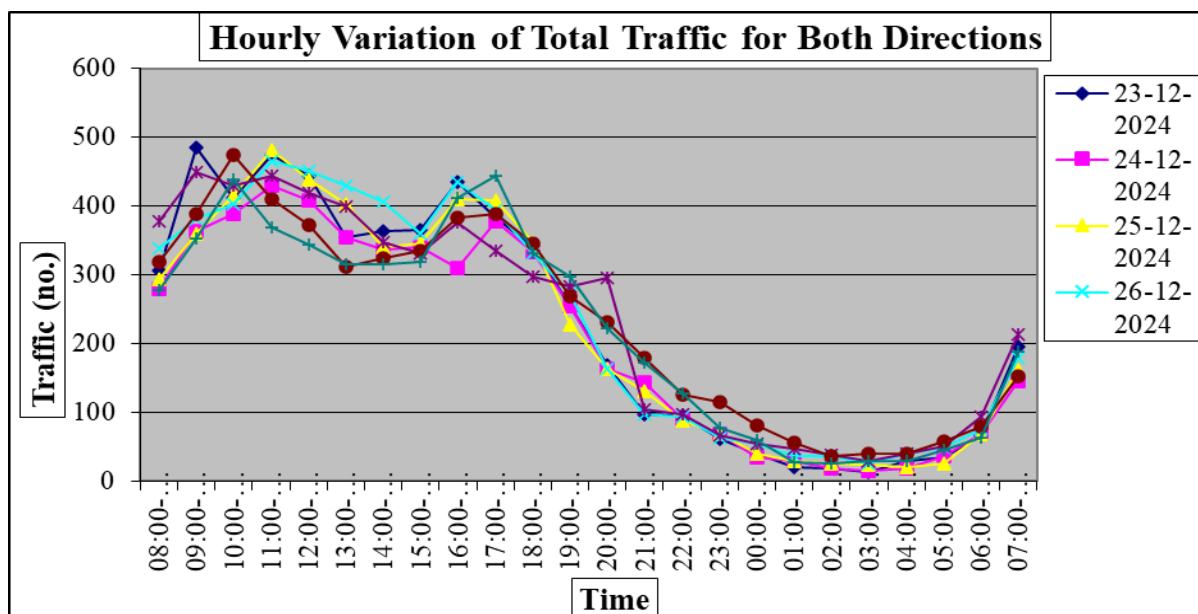


Figure 4.9: Hourly Variation of Total Traffic for Both Directions at km 52+200

It is seen that traffic drops significantly at night between 9 pm to 4 am. This is due to the fact that traffic comprises mainly of passenger vehicles which is dependent upon the movement of the local residents during daylight hours.

4.3.5 Directional Distribution

The directional distribution of tollable traffic for UP Direction v/s DN Direction has been worked out; the directional split follows as:

1. CVC-1 at km 9+430 (Ch 41+833)

Table 4.8: Directional Distribution of Total & Tollable Traffic (%) CVC-1

CVC No.	Location	DN Direction (Jamnagar-Kalavad)	UP Direction (Kalavad-Jamnagar)
CVC-1	Km 9+430	Total Traffic – 50.5% Tollable Traffic – 50.44%	Total Traffic – 49.5% Tollable Traffic – 49.56%

The directional distribution graphs for all vehicle categories for survey location are as follows:

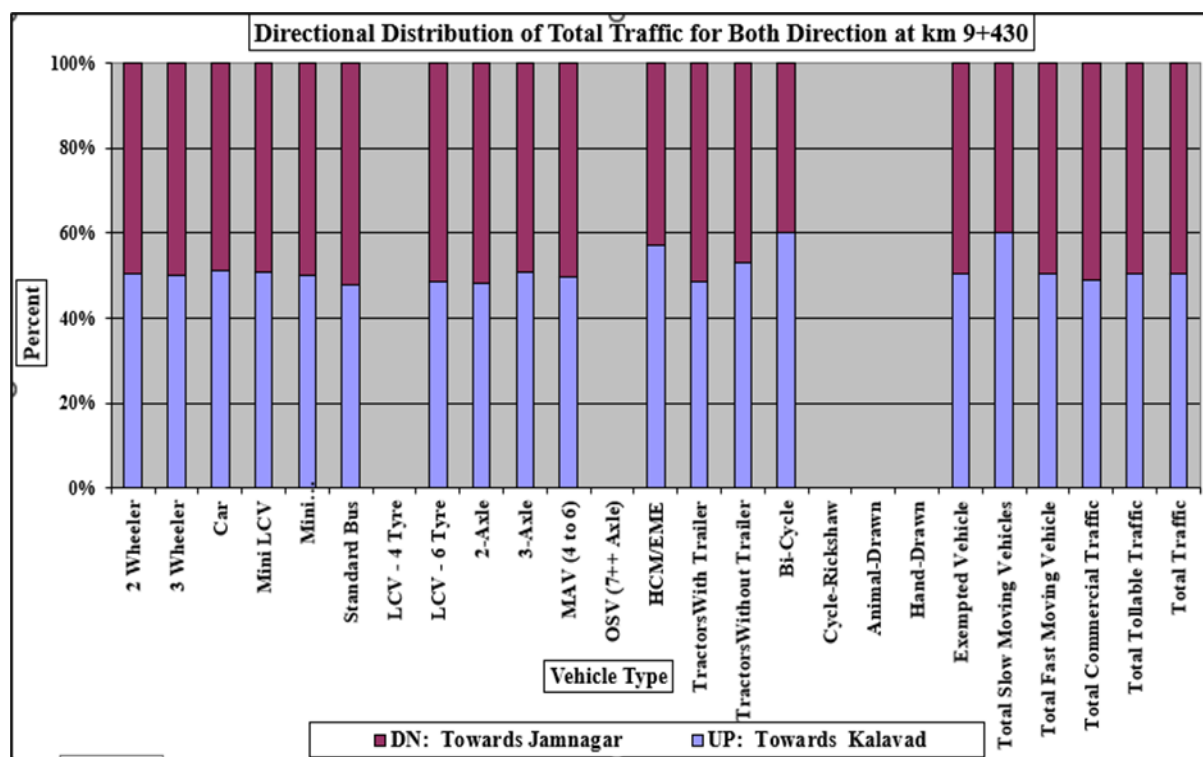


Figure 4.10: Directional Distribution of Total Traffic for Both Directions at km 9+430

2. CVC-2 at km 52+200

Table 4.9: Directional Distribution of Total & Tollable Traffic (%) CVC-2

CVC No.	Location	DN Direction (Dhoraji-Kalavad)	UP Direction (Kalavad-Dhoraji)
CVC-2	Km 52+200	Total Traffic – 49.51% Tollable Traffic – 49.32%	Total Traffic – 50.49% Tollable Traffic – 50.68%

The directional distribution graphs for all vehicle categories for survey location are as follows:

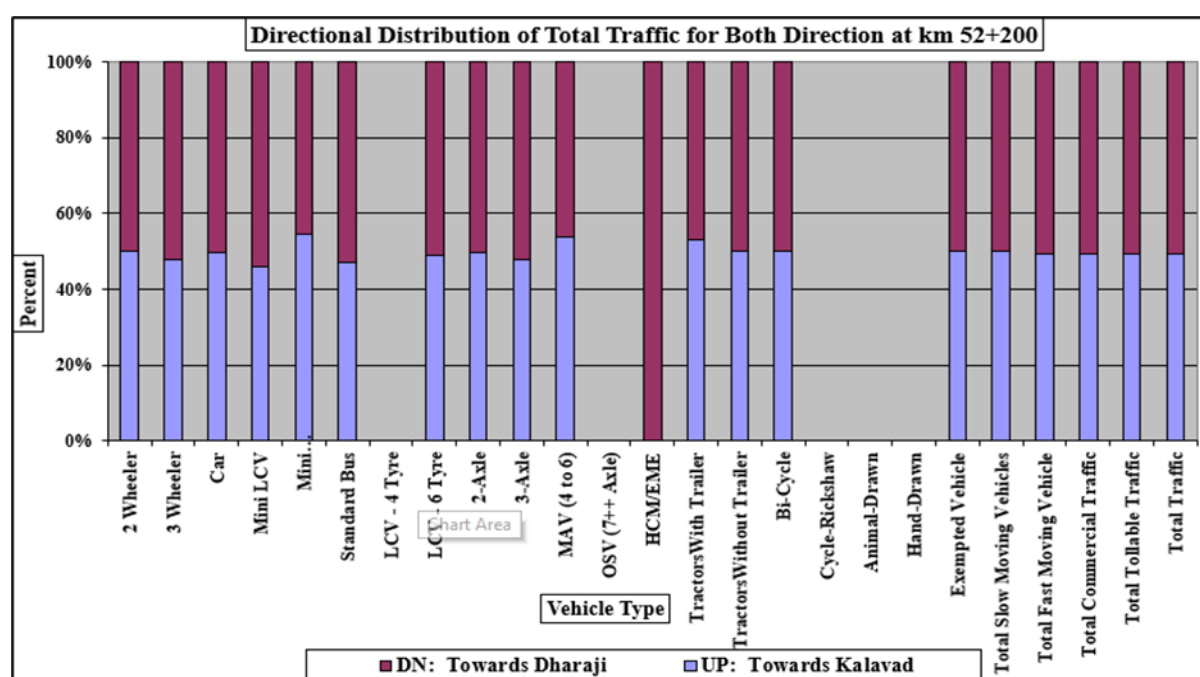


Figure 4.11: Directional Distribution of Total Traffic for Both Directions at km 52+200

4.3.6 Annual Average Daily Traffic (AADT)

The calculation for Annual Average Daily Traffic (AADT) is done by multiplying the ADT values with Seasonal Variation Factors (SVF). Seasonal variation factors by vehicle types are required to account for variations in the pattern of traffic volume on the project road sections over different months or seasons of the year. There are various methods of determining the seasonal factors such as through past traffic count data or secondary data (fuel sales data or toll plaza data). The past traffic count methodology is useful if it is carried out round the year, but year-round counts are seldom done in India on any road. Therefore, the seasonal factors are generally calculated through secondary data. Since there is no fuel sales data has been collected along the project highway, we assumed that Seasonal Variation Factor (SVF) as 1 for all types of vehicles.

Since the SVF values are assumed as 1, the ADT and AADT will be the same. The Annual Average Daily Traffic in Vehicles and PCU are given below:

Table 4.10: Annual Average Daily Traffic (AADT) for CVC-1 at km 9+430

Categories	UP				DN				Both Directions			
	As per 2024 Survey		As per 2015 Survey		As per 2024 Survey		As per 2015 Survey		As per 2024 Survey		As per 2015 Survey	
	Vehicles	PCU	Vehicles	PCU	Vehicles	PCU	Vehicles	PCU	Vehicles	PCU	Vehicles	PCU
2-Wheeler	2,476	1,238	2,116	1,058	2,539	1,270	1,982	991	5,015	2,508	4,098	2,049
3-Wheeler	285	285	313	313	286	286	304	304	571	571	617	617
Car	1,557	1,557	907	907	1,625	1,625	813	813	3,182	3,182	1,720	1,720
Mini LCV	259	259	174	174	267	267	207	207	526	526	381	381
Mini Bus	4	6	18	27	4	6	26	39	8	12	44	66
Standard Bus	99	149	118	354	91	137	109	327	190	286	227	681
LCV - 4 Tyre	0	0	27	41	0	0	40	60	0	0	67	101
LCV - 6 Tyre	177	266	78	117	166	249	100	150	343	515	178	267
2-Axle	216	648	201	603	201	603	178	534	417	1,251	379	1,137
3-Axle	73	219	260	780	75	225	175	525	148	444	435	1,305
MAV (4 to 6)	97	437	201	905	96	432	98	441	193	869	299	1,346
OSV (7++ Axle)	0	0	5	23	0	0	5	23	0	0	10	46
HCM/EME	3	14	6	27	4	18	8	36	7	32	14	63
Tractors With Trailer	49	221	64	288	46	207	65	293	95	428	129	581
Tractors Without Trailer	8	12	10	15	9	14	13	20	17	26	23	35

Categories	UP				DN				Both Directions			
	As per 2024 Survey		As per 2015 Survey		As per 2024 Survey		As per 2015 Survey		As per 2024 Survey		As per 2015 Survey	
Bi-Cycle	2	1	25	13	3	2	21	11	5	3	46	24
Cycle-Rickshaw	0	0	1	2	0	0	0	0	0	0	1	2
Animal-Drawn	0	0	5	30	0	0	9	54	0	0	14	84
Hand-Drawn	0	0	1	3	0	0	0	0	0	0	1	3
Exempted Vehicle	56	56	14	14	57	57	15	15	113	113	29	29
Total Slow-Moving Vehicles	2	1	32	48	3	2	30	65	5	3	62	113
Total Fast-Moving Vehicle	5,359	5,367	4,512	5,646	5,466	5,396	4,138	4,778	10,825	10,763	8,650	10,424
Total Commercial Traffic	669	1,739	914	2,877	637	1,670	739	2,135	1,306	3,409	1,653	5,012
Total Tollable Traffic	2,485	3,555	1,995	3,958	2,529	3,562	1,759	3,155	5,014	7,117	3,754	7,113
Total Traffic	5,361	5,368	4,544	5,694	5,469	5,398	4,168	4,843	10,830	10,766	8,712	10,537

The above table provides data and comparison of the total traffic for the road segment CVC-1 conducted at km 9+430 on year 2024 and CVC – 1 at km 10+000 on year 2015.

At km 9+430, the UP direction, the total number of vehicles is 5,361, while in the DOWN direction, it is 5,469 resulting in a combined total of 10,830 vehicles. For the PCU (Passenger Car Unit) values, the UP direction has 5,368 PCU, and the DOWN direction has 5,398 PCU, leading to a total of **10,766 PCU**.

At km 10+000, The total number of vehicles found that 8,712 and total of 10,537 PCU. As we compare with present traffic, the total number of vehicles increased to 2,118 Vehicles and PCU's are more or less same.

Table 4.11: Annual Average Daily Traffic (AADT) for CVC-2 at km 52+200

Categories	CVC-2 km 52+200					
	UP		DN		Both Directions	
	Vehicles	PCU	Vehicles	PCU	Vehicles	PCU
2-Wheeler	1,028	514	1,024	512	2,052	1,026
3-Wheeler	159	159	146	146	305	305
Car	1,046	1,046	1,036	1,036	2,082	2,082
Mini LCV	148	148	125	125	273	273
Mini Bus	5	8	6	9	11	17
Standard Bus	69	104	61	92	130	196
LCV - 4 Tyre	0	0	0	0	0	0
LCV - 6 Tyre	44	66	42	63	86	129
2-Axle	93	279	92	276	185	555
3-Axle	47	141	43	129	90	270
MAV (4 to 6)	48	216	56	252	104	468
OSV (7++ Axle)	0	0	0	0	0	0
HCM/EME	1	5	0	0	1	5
Tractors With Trailer	32	144	36	162	68	306
Tractors Without Trailer	1	2	1	2	2	4
Bi-Cycle	2	1	2	1	4	2
Cycle-Rickshaw	0	0	0	0	0	0
Animal-Drawn	0	0	0	0	0	0

Categories	CVC-2 km 52+200					
	UP		DN		Both Directions	
	Vehicles	PCU	Vehicles	PCU	Vehicles	PCU
Hand-Drawn	0	0	0	0	0	0
Exempted Vehicle	1	1	1	1	2	2
Total Slow-Moving Vehicles	2	1	2	1	4	2
Total Fast-Moving Vehicle	2,722	2,833	2,669	2,805	5,391	5,638
Total Commercial Traffic	307	819	300	821	607	1,640
Total Tollable Traffic	1,501	2,013	1,461	1,982	2,962	3,995
Total Traffic	2,724	2,834	2,671	2,806	5,395	5,640

The above table provides data on the total Annual traffic for the road segment CVC-2 Dhoraji to Kalavad. In the UP direction, the total number of vehicles is 2,724, while in the DOWN direction, it is 2,671, resulting in a combined total of 5,395 vehicles. For the PCU (Passenger Car Unit) values, the UP direction has 2,834 PCU, and the DN direction has 2,806 PCU, a total of **5,640 PCU**.

4.4 ANALYSIS OF AXLE LOAD SURVEY DATA

4.4.1 Introduction

The intensity of traffic loading and corresponding damaging of different categories of vehicles is an important parameter for the design of pavements. The primarily objective of axle load survey is to determine the Vehicle Damaging Factor (VDF) of commercial vehicles and over loading.

The survey was conducted near Thavariya village at km 9+430 for 1 day (24 hrs.) on random sampling basis to cover directional traffic for both empty and loaded commercial vehicles using portable weighing pads.

The survey was carried out on random sampling basis to cover directional traffic for both empty and loaded commercial vehicles, i.e. LCVs, 2-Axle, 3-Axle, Multi Axle Trucks and Buses. The drivers were directed to stop their vehicles in such a way that wheel of each axle can be weighed using portable Axle Load Weighing Pad.

4.4.2 Load Equivalency Factors

Equivalency is a convenient means for indexing the wide spectrum of actual loads to one selected value, defined as “Equivalent Axle Load (EAL)”. One of the most important and useful products of AASHTO Road Test was the development of a relationship characterizing the relative damaging effect of varying axle load on pavements in terms of equivalent 80 kN

standard axle load. This relationship sometimes referred the “**Fourth Power**” rule has subsequently been verified by studies reported by several agencies in different countries.

As per the guidelines of IRC: 37-2012, the equations used for computing equivalency factors for single, tandem & tridem axles are mentioned below:

$$\text{Single axle with single wheel} = (\text{Axle load in kN}/65)^4$$

$$\text{Single axle with dual wheel} = (\text{Axle load in kN}/80)^4$$

$$\text{Tandem axle with dual wheel} = (\text{Axle load in kN}/148)^4$$

$$\text{Tridem axle with dual wheel} = (\text{Axle load in kN}/224)^4$$

The values mentioned above are in terms of kN which is further converted into kgs, as the collected load data during the surveys is also in the same unit. The Total Equivalencies factors are obtained for each category from “**Fourth Power**” rule as the product of numbers of vehicles sampled and load equivalency factor.

$$\text{Total EAL} = \sum (\text{Number of Vehicles in each weight class} \times \text{Load Equivalency Factor of weight Class})$$

4.4.3 Vehicle Damage Factor

The Vehicle Damaging factor (VDF) is an indexing factor for characterizing the traffic loading of the road. The VDF can easily be computed from the axle load data, provided sufficiently large and fairly distributed sample of vehicles are included in the axle load survey. The vehicle damage factor is a multiplier to convert the number of commercial vehicles of different axle loads and axle configuration to the number of standard axle load repetitions. It is defined as equivalent number of standard axles per commercial vehicle. The VDF varies with the vehicle axle configuration, axle loading scenario and no of traffic. VDF is calculated using following formula:

$$\text{VDF} = \text{Total EAL} / \text{No. of vehicles Weighed}$$

The summarized sample details & VDF values are presented in **Table 4.12 & Table 4.13** given below.

Table 4.12: % Sample Collected of Total Traffic

Vehicle Type	Kalavad to Jamnagar	Jamnagar to Kalavad
	UP	DN
Bus	0.00%	0.00%
LCV + Mini LCV	7.80%	18.71%
2 Axle Truck	29.17%	35.82%

Vehicle Type	Kalavad to Jamnagar	Jamnagar to Kalavad
	UP	DN
3 Axle Truck	52.05%	25.33%
MAV+HCM/EME Tractor	15.29%	7.74%

Table 4.13: Calculated VDF

Vehicle Type	Kalavad to Jamnagar	Jamnagar to Kalavad
	UP	DN
Bus	-	-
LCV + Mini LCV	0.37	0.27
2 Axle Truck	7.62	2.94
3 Axle Truck	7.56	5.10
MAV+HCM/EME Tractor	9.81	14.09

The calculated values are further adopted based on IRC 37 2018.

Table 4.14: Recommended VDF

Vehicles	At km 9+430 THAVARIYA VILLAGE	
	VDF	Remarks
Bus	0.80	Values adopted based on the past experience
LCV + Mini LCV	0.31	Values adopted as per the axle load survey
2 Axle Truck	7.62	Values adopted as per the axle load survey
3 Axle Truck	7.56	Values adopted as per the axle load survey
MAV+HCM/EME Tractor	14.09	Values adopted as per the axle load survey

4.5 TRAFFIC FORECAST

Traffic forecasting is at best an approximation, which is based on analysis of available data. Traffic is generated as a result of the interplay of a number of contributory factors, some of which are difficult to estimate with their trend in economy. Forecasts of traffic have, therefore, to be dependent on the forecasts factors such as Vehicle Ownership, Net National Product (NNP), Net State Domestic Product (NSDP), & Per Capita Income (PCI). Future pattern of change in these factors can be estimated with only a limited degree of accuracy and hence the forecasting of future traffic levels cannot be precise.

In absence of such data, IRC 37 2018 recommends the growth rate of 5% and same has been used for calculating projected traffic. Traffic projections were made by applying the growth rates to the base year (2024) traffic. Projections are undertaken up to time horizon year 2044-45 (20 years).

Table 4.15: Projected Normal Traffic in AADT (PCU) for CVC-1

S. No.	Year	Total AADT (PCU)
		Km 9+340
1	2024	10,766
2	2025	11,304
3	2026	11,870
4	2027	12,463
5	2028	13,086
6	2029	13,740
7	2030	14,427
8	2031	15,149
9	2032	15,906
10	2033	16,702
11	2034	17,537
12	2035	18,414
13	2036	19,334
14	2037	20,301
15	2038	21,316
16	2039	22,382
17	2040	23,501
18	2041	24,676
19	2042	25,910
20	2043	27,205
21	2044	28,565
22	2045	29,994

Table 4.16: Projected Normal Traffic in AADT (PCU) for CVC-2

S. No.	Year	Total AADT (PCU)
		km 52+200
1	2024	5,640

S. No.	Year	Total AADT (PCU)
		km 52+200
2	2025	5,922
3	2026	6,218
4	2027	6,529
5	2028	6,855
6	2029	7,198
7	2030	7,558
8	2031	7,936
9	2032	8,333
10	2033	8,749
11	2034	9,187
12	2035	9,646
13	2036	10,129
14	2037	10,635
15	2038	11,167
16	2039	11,725
17	2040	12,311
18	2041	12,927
19	2042	13,573
20	2043	14,252
21	2044	14,965
22	2045	15,713

4.6 DESIGN TRAFFIC

As per IRC 37, the design traffic in terms of the cumulative number of standard axles to be carried during the design period is estimated using the following equation:

$$N_{Des} = \frac{365 \times [(1 + r)^n - 1]}{r} \times A \times D \times F$$

Where:

- N_{Des} = Cumulative number of standard axles to be catered for during the design period of n years.
- A = Initial traffic (commercial vehicles per day) in the year of completion of construction.
- D = Lateral distribution factor

- F = Vehicle damage factor (VDF).
- n = Design period in years. (Assumed as 20 years)
- r = Annual growth rate of commercial vehicles (Assumed as 5%)

Additionally, the traffic in the year of completion of construction (A) can be estimated using the following equation:

$$A = P \times (1 + r)^x$$

Where:

- P = Number of commercial vehicles per day as per the last traffic count.
- x = Number of years between the last traffic count and the year of completion of construction.

Detailed calculation of projected design traffic has been presented in **Annexure-4.1**. However, summary of design traffic has been shown below.

Table 4.17: Design Traffic in MSA

Location	Direction	Year			
		5 Year	10 Year	15 Year	20 Year
CVC -1 at km 9+430	Kalavad To Jamnagar [UP]	7.3	16.7	28.7	44.0
CVC -1 at km 9+430	Jamnagar To Kalavad [DN]	7.1	16.2	27.9	42.7
CVC -2 km 52+200	Kalavad To Jamnagar [UP]	3.7	8.5	14.5	22.2
CVC -2 km 52+200	Jamnagar To Kalavad [DN]	3.9	8.8	15.1	23.2

Adopted design traffic for pavement design as per the recent traffic survey is presented below,

S. No.	Section	Adopted Design Traffic	
		Kalavad to Jamnagar [UP]	Jamnagar to Kalavad [DN]
1	4-Laning of existing c/way and proposed realignment	44	44
2	4-lane proposed Kalavad Bypass	44	44

4.7 ANALYSIS OF ORIGIN DESTINATION SURVEY

The Origin destination survey was conducted at km 9+430 (Ch 41+833) near Mota Thavariya Village for 1 day 24 hrs. Roadside Interview Method was adopted for conducting the survey. The vehicles were stopped at random under police presence and drivers were interviewed by trained enumerators to collect the needful information/ data. The pertinent information in respect of travel characteristics including the following were collected during these interviews:

- Origin and Destination details of the trip makers
- Trip length
- Trip Frequency
- Trip Purpose
- Commodity Type and load



Figure 4.12: OD Survey photographs at Km 9+430

4.7.1 Zoning system

In order to assess the movement pattern of traffic on the project influence area, a zoning system has been developed keeping in view the major trip generation & distribution points. The details of the traffic zones adopted for the study are presented in the table below. The project influence area mainly comprises of Immediate Influence Area (Zones along project corridor), Intermediate Influence Area (other zones of Gujarat state) & Broad Influence Area (Rest of the states).

Table 4.18: Traffic Zoning System & Zone Codes

Zone Code	Zone Description	Region
1	Jamnagar, Lalpur, GIDC, Gulab Nagar, Udhyog Nagar, Ashapura, Satyam Colony, Bypass, Gokul Nagar, Relience, Bedeshwar, Sewa Sadan (Dwarka), Patel Colony, Naghedi, Ranjit Nagar, Mayur Nagar, Shakti Nagar, Sat Rasta (Jamnagar), Mandi Jamnagar, Nawagaum, Khodiyar Colony, Airport Jamnagar, Subhash Market, Kamdar Colony, Krishna Nagar, Markanda, Wasai, Kulpnagar	Jamnagar
2	Kalavad	Kalavad
3	Vijarkhi	Vijarkhi
4	Rajkot, Khandera, Bedi Chokdi	Rajkot
5	Theba	Theba
6	Hapa	Hapa
7	Junagarh, Sukhpur, Green City, Joshipura, Jaunpur	Junagarh
8	Dwarka, Khambhalia	Dwarka
9	Dhoraji	Dhoraji
10	Sapda	Sapda
11	Moti Matali	Moti Matali
12	Sikka, Vadinar	Sikka
13	Porbandar, Taran Patiya	Porbandar
14	Nikava, Lodhika, Sapar	Nikava
15	Jamwali, Sarvania	Jamwali
16	Jetpur	Jetpur
17	Modpar	Modpar
18	Kalyanpur	Kalyanpur
19	Chandrapur, Thangadh, Dhuva, Wakaner, Nani Vavdi, Badarghadh, Pada Pul	Chandrapur
20	Darbar Garh, Bhawnagar, Navagadh, Dared	Bhawnagar
21	Matwa, Aurwa, Jalsan, Ahmedabad, Sikwada, Palanpur, Mumbai, Jaspur, Daman, Surat, Martoli, Essar, Sarori, Vapi, Guna (Gujarat), Badarghadh, Pune, Sarori, Samarpada, Bel Tikri, Bikaner, Boriya, Dhaulpur, Khoripada, Sarori	Ahmedabad and Rest of Gujarat, including Mumbai
22	Surendra Nagar	Surendra Nagar
23	Mota Bhandariya, Bagasara, Shanti Nagar, Amreli,	Amreli

Zone Code	Zone Description	Region
	Dhari, Mityala, Kodiya, Kodinar	
24	Anandpur	Anandpur
25	Harshadpur	Harshadpur
26	Gondal	Gondal
27	Sachana, Moti Banugar	Sachana

4.7.2 Commodity Groups

After coding of Origin – Destination data, a variety of commodity movement is found on the project road, the commodities were categorized and allotted codes as presented in the table below. Due consideration has been given to include all possible commodities and are categorized into homogeneous groups. Composition of commodity movement for all categories combined is given below in the form of bar charts for each location.

Table 4.19: Commodity Codes for the Project Road

Commodity Code	Commodity Type	Description
1	Empty	no load
2	Perishable Products	chicken, mik, milk
3	Food Crops	peanut, penaut
4	Cash Crops	kapan, kapas
5	Electricals & Electronics	cable, machine, wire
6	Consumer Products	animal feed, chaara, cheeni, chips, dabar, fortune, fourtune, fruits, ganna, khaad, machhli, namkeen, oil, oil, onion, sabzi, seeds
7	Chemical Products	chemical, medicine, powder
8	Petroleum Products	diesel, petrol
9	Textile Products	cloth, kapda
10	Building Materials	dawar, gitti, kakri, karki, khamba, kokri, mitti, moti, pathar, reli, reta, rodi, sariya, tile
11	Cement	cement, flash
12	Parcel & Paper Products	kagaj, paper, parcel, roll paper
13	Wood and Forest Products	lakdi, lathi
14	Automobile Spare Parts & Machinery	-
15	Metals	bartan, loha, scrap, steel

Commodity Code	Commodity Type	Description
16	Minerals & Ores	-
17	Rubber & Plastic Products	bottle, drum, plastic, toys
18	Miscellaneous	kachra, murti

4.7.3 Travel Pattern

The analysis of travel pattern reveals that about majority of trips are within the project corridor & within the state and negligible trips to other states. The mode wise distribution of trips (%) across various regions mentioned above is as follows:

Table 4.20: Mode wise Distribution of Trips (%) at km 9+430

Zones	CAR	MINI BUS	STD. BUS	MINI LCV	LCV	2-AXLE	3-AXLE	MAV
Jamnagar	28%	40%	39%	31%	35%	36%	33%	31%
Kalavad	15%	10%	17%	12%	11%	5%	4%	5%
Vijarkhi	3%	10%	1%	10%	9%	19%	9%	8%
Rajkot	5%	20%	7%	10%	10%	9%	12%	15%
Theba	6%	0%	1%	6%	2%	1%	1%	2%
Hapa	3%	0%	2%	8%	4%	3%	2%	1%
Junagarh	5%	0%	11%	2%	4%	1%	4%	8%
Dwarka	3%	0%	4%	2%	1%	1%	1%	3%
Dhoraji	2%	0%	2%	0%	3%	2%	2%	2%
Sapda	2%	0%	1%	2%	0%	0%	1%	1%
Moti Matali	2%	0%	2%	0%	1%	1%	1%	0%
Sikka	1%	0%	0%	0%	0%	2%	3%	4%
Porbandar	1%	0%	1%	0%	2%	1%	3%	5%
Nikava	3%	0%	0%	2%	1%	1%	1%	1%
Jamwali	3%	0%	0%	0%	1%	1%	1%	1%
Jetpur	1%	0%	0%	0%	1%	1%	3%	0%
Modpar	1%	0%	1%	0%	0%	0%	0%	0%
Kalyanpur	1%	0%	1%	2%	1%	1%	1%	0%
Chandrapur	1%	0%	0%	4%	1%	1%	0%	3%
Bhawnagar	2%	10%	1%	8%	0%	3%	3%	2%
Ahmedabad and Rest of	1%	0%	1%	0%	1%	1%	0%	0%

Zones	CAR	MINI BUS	STD. BUS	MINI LCV	LCV	2-AXLE	3-AXLE	MAV
Gujarat, including Mumbai								
Surendra Nagar	3%	0%	1%	2%	4%	4%	4%	3%
Amreli	0%	0%	0%	0%	0%	0%	1%	0%
Anandpur	0%	0%	0%	0%	0%	0%	1%	0%
Harshadpur	0%	0%	0%	2%	0%	0%	1%	0%
Gondal	2%	0%	1%	0%	1%	0%	1%	0%
Sachana	6%	10%	7%	0%	5%	4%	9%	7%
Total	100%	100%	100%	100%	100%	100%	100%	100%

The OD analysis indicates that most trips were confined within Gujarat, with no trips extending to other states from the surveyed road. Major locations where OD sample trips were observed include Jamnagar, Kalavad, Vijarkhi, Rajkot, Hapa, Junagarh, Bhavnagar, Surendra Nagar, and Sachana.

4.7.4 Commodity Analysis

The commodity distribution at toll location followed by the major commodities carried directionally is mentioned below:

Table 4.21: Commodity Analysis @ km 9+430

S. No.	Frequency	ML	LCV	2 Axle	3 Axle	MAV
1	Empty	35%	49%	36%	45%	37%
2	Perishable Products	4%	4%	0%	0%	2%
3	Food Crops	0%	3%	0%	0%	0%
4	Cash Crops	0%	1%	1%	0%	0%
5	Electricals & Electronics	0%	1%	2%	3%	2%
6	Consumer Products	31%	16%	16%	24%	19%
7	Chemical Products	0%	4%	3%	2%	5%
8	Petroleum Products	0%	1%	1%	2%	0%
9	Textile Products	4%	1%	1%	3%	5%
10	Building Materials	0%	9%	24%	11%	7%
11	Cement	4%	2%	1%	1%	7%
12	Parcel & Paper Products	8%	2%	2%	0%	0%

S. No.	Frequency	ML	LCV	2 Axle	3 Axle	MAV
13	Wood and Forest Products	4%	3%	1%	1%	3%
14	Automobile Spare Parts & Machinery	0%	0%	0%	0%	0%
15	Metals	8%	3%	3%	4%	10%
16	Minerals & Ores	0%	0%	0%	0%	0%
17	Rubber & Plastic Products	0%	1%	1%	2%	0%
18	Miscellaneous	4%	3%	9%	1%	3%
Total		100%	100%	100%	100%	100%

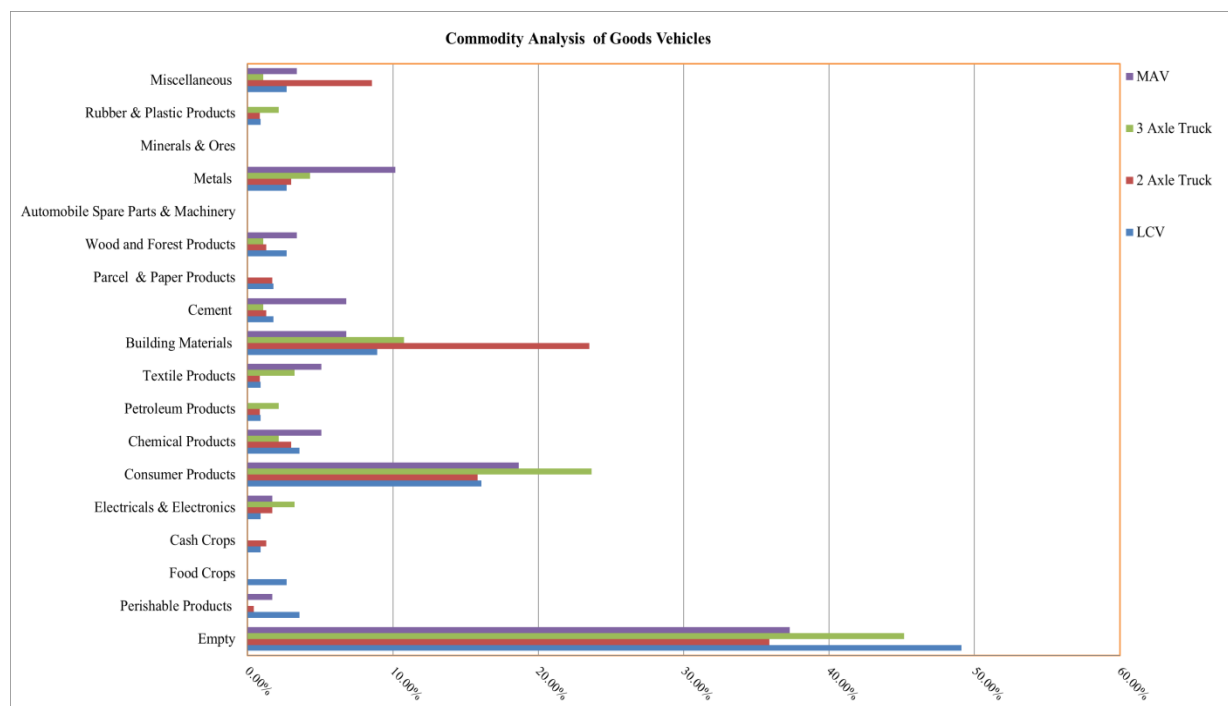


Figure 4.13: Commodity Distribution Graph of location km 9+430

As per the Origin-Destination (OD) survey, it was observed that about 40% of the goods carriers were traveling empty. ML and LCVs were primarily engaged in transporting consumer goods and parcels, On the other hand, 2-Axle and 3-Axle trucks were predominantly used for carrying building materials and cement, highlighting their role in construction-related logistics. Meanwhile, MAVs were chiefly utilized for transporting metals and chemicals.

The directional major commodities at km 9+430 are as given below:

Table 4.22: Major Commodities directional wise at km 9+430

Commodity Type	LCV	2 Axle	3 Axle	MAV
Dhoraji to Jamnagar				
Empty	45%	41%	20%	36%
Electricals & Electronics	0%	2%	3%	2%
Consumer Products	27%	20%	14%	20%
Chemical Products	0%	2%	4%	5%
Petroleum Products	0%	2%	2%	2%
Textile Products	0%	0%	0%	2%
Building Materials	0%	17%	37%	18%
Cement	9%	0%	3%	2%
Wood and Forest Products	0%	0%	2%	2%
Metals	9%	0%	3%	2%
Rubber & Plastic Products	0%	2%	1%	5%
Total of Above	91%	88%	87%	98%
Jamnagar to Dhoraji				
Empty	27%	54%	52%	53%
Perishable Products	7%	6%	1%	0%
Electricals & Electronics	0%	1%	0%	0%
Consumer Products	0%	0%	2%	0%
Chemical Products	0%	0%	1%	4%
Textile Products	33%	14%	18%	27%
Building Materials	0%	4%	2%	0%
Cement	0%	0%	0%	2%
Parcel & Paper Products	0%	4%	9%	4%
Wood and Forest Products	13%	3%	3%	0%
Metals	0%	0%	0%	0%
Total of Above	80%	86%	88%	90%

4.7.5 Lead Analysis

The O-D survey data has been further analyzed to obtain lead and ranges for various passenger and goods vehicles. The trip length frequency distribution in terms of proportion for the selected range is presented in **Table 4.23**.

Table 4.23: Mode Wise Distribution of Trips by Various Lead Ranges (%) for passenger vehicles

Trip Length	Car/Taxi	Mini Bus	Standard Bus (Govt. & Pvt.)
0-25	8%	20%	5%
25-50	40%	60%	34%
50-100	24%	20%	12%
100-150	16%	0%	31%
150-200	7%	0%	8%
200-300	3%	0%	7%
300-400	1%	0%	1%
400-500	0%	0%	0%
500-1000	0%	0%	1%
>1000	0%	0%	0%
Total Vehicles	100%	100%	100%

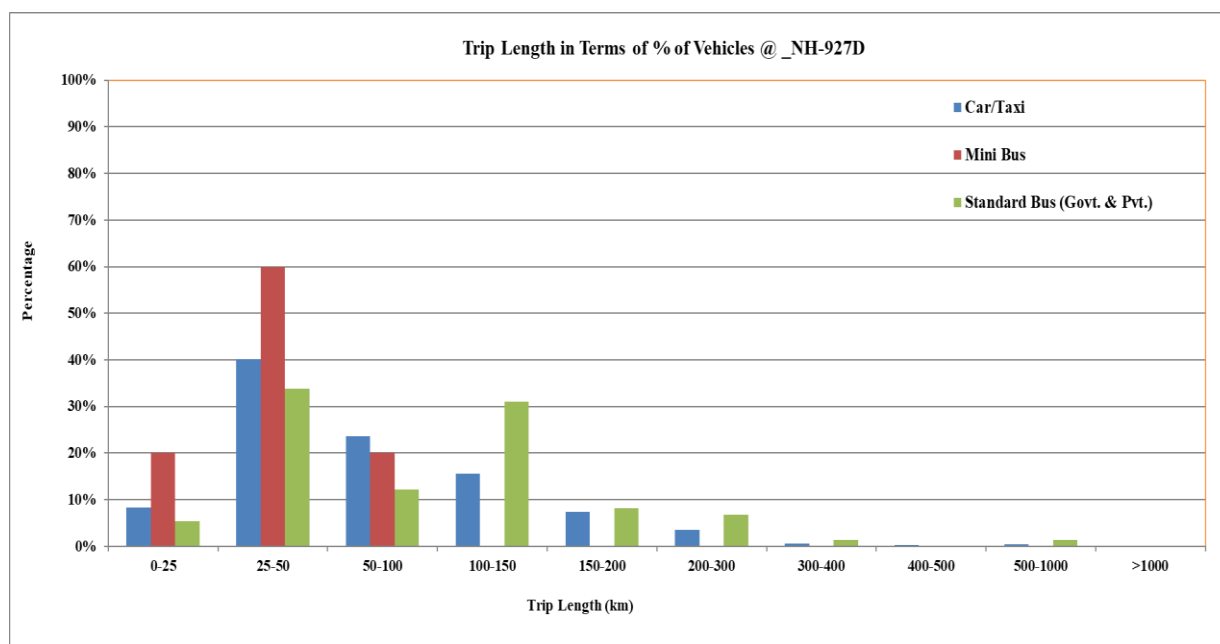


Figure 4.14: Goods vehicle Trip Length Graph of location km 9+430

It was observed that the majority of passenger trips range between 25 km and 300 km, with passenger trips predominantly confined to Gujarat. Additionally, only 2% of private and government buses travel distances exceeding 300 km.

Table 4.24: Mode Wise Distribution of Trips by Various Lead Ranges (%) of Goods vehicles

Trip Length	ML	LCV	2 Axle	3 Axle	MAV
0-25	19%	13%	26%	13%	12%
25-50	23%	30%	26%	19%	19%
50-100	8%	20%	16%	18%	12%
100-150	27%	21%	15%	17%	20%
150-200	15%	8%	7%	11%	12%
200-300	0%	4%	5%	9%	10%
300-400	0%	1%	1%	1%	2%
400-500	0%	1%	0%	0%	3%
500-600	4%	1%	1%	2%	5%
600-700	4%	0%	0%	1%	0%
700-800	0%	1%	1%	2%	0%
800-900	0%	1%	0%	2%	3%
900-1000	0%	0%	0%	2%	0%
1000-1500	0%	1%	0%	2%	2%
>1500	0%	0%	0%	0%	0%
Total Vehicles	100%	100%	100%	100%	100%

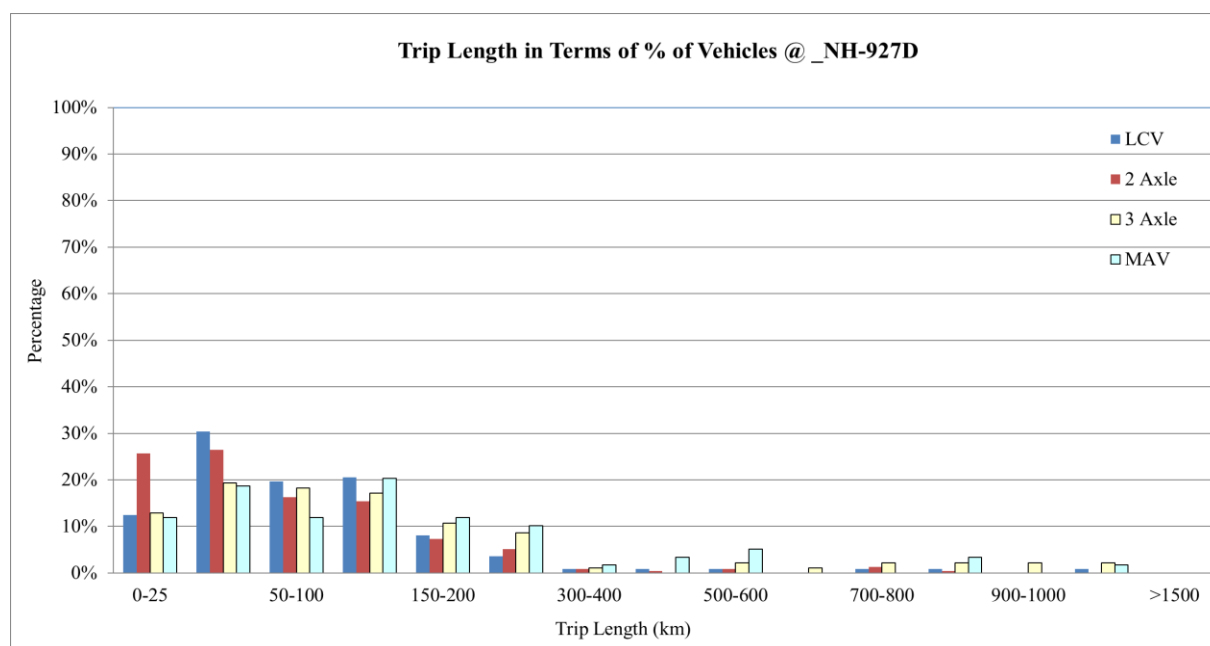


Figure 4.15: Goods vehicle Trip Length Graph of location km 9+430

The majority of goods traffic travels distances between 25 km and 300 km, indicating that most of the traffic is concentrated within local to regional transport routes. However, MAV trucks have trips greater than 300 kms.

4.7.6 Through traffic Analysis

Based on the Origin-Destination survey data and classified volume count data collected, the analysis indicates that a significant proportion of the traffic originating from Jamnagar or destined to Jamnagar is likely to utilize the proposed bypass.

The total sample collected through OD survey is mentioned below in the table:

Table 4.25: Origin Destination Survey Total Sample

Vehicle Type	Jamnagar to Dhoraji	Dhoraji to Jamnagar
Car	865	1061
Mini Bus	6	0
Standard Bus	82	67
Mini LCV	142	182
LCV	95	150
2 Axle Truck	155	150
3 Axle Truck	49	56
MAV	39	88
Total	1,434	1,754
Both Directional Total	3,188	

According to the analysis, traffic originating from Jamnagar and destined for Dhoraji, or generally heading south of Gujarat, will utilize the Kalavad bypass instead of entering Kalvad city. Additionally, traffic traveling towards Rajkot via SH-23 will also partially use the Kalavad bypass. Based on these assumptions, the traffic expected to use the Kalavad bypass has been calculated as outlined below:

Table 4.26: Total sample that will use the Kalavad Bypass

Vehicle Type	Jamnagar to Dhoraji	Dhoraji to Jamnagar
Car	433	456
Mini Bus	3	0
Standard Bus	59	28
Mini LCV	61	142
LCV	55	76
2 Axle Truck	57	71
3 Axle Truck	32	38

Vehicle Type	Jamnagar to Dhoraji	Dhoraji to Jamnagar
MAV	26	59
Total	726	870
Both Directional Total	1,596	

Table 4.27: Total sample % that will use the Kalavad Bypass

Vehicle Type	Jamnagar to Dhoraji	Dhoraji to Jamnagar
Car	50%	43%
Mini Bus	50%	-
Standard Bus	72%	42%
Mini LCV	43%	78%
LCV	58%	51%
2 Axle Truck	37%	48%
3 Axle Truck	65%	69%
MAV	67%	67%
Total	51%	50%
Both Directional Total	52%	

The analysis predicts that approximately 52% of the total tollable traffic currently using the existing project road will divert to the Kalavad bypass. This includes traffic traveling from Jamnagar to Dhoraji and beyond, as well as vehicles heading towards Rajkot via SH-23, effectively reducing congestion on the existing road network.

4.8 CONCLUSION

As per the CVC data received there is not much variation in traffic and overall traffic in 2015 and 2024 is almost same. The current commercial traffic is less than in 2015.

- However, current traffic is more than **10,000** and therefore it is suggested to keep the 4-lane proposal between Kalavad (end of Kalavad bypass) to Jamnagar.
- As per the Origin-Destination data analysis conducted at 9+430 near Mota Thavariya Village location, approximately **52%** of Tollable traffic currently using the existing project road is expected to divert to the Kalavad Bypass.
- MSA will be change to **44** instead of 51 in the LHS direction and **44** instead of 35 in the RHS direction.

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CHAPTER - 5
METHODOLOGY ADOPTED INCLUDING
SURVEYS, ANALYSIS, AND DESIGNS &
OUT COMES

CHAPTER - 5

METHODOLOGY ADOPTED INCLUDING SURVEYS, ANALYSIS, AND DESIGNS & OUT COMES

5.1 INTRODUCTION

This chapter deals with brief description of the topographical survey carried out along the project corridor. The basic objective of the topographic survey is to capture the essential ground features along the alignment in order to consider widening to 2/4 lane, improvements and for working out detailed design, working drawings, quantity and cost estimation, land acquisition, shifting of utilities, removal of plantation, road side drainage design and related features. The topographical features mainly includes establishment of permanent traverse stations for GPS and temporary bench marks, longitudinal section levels, cross sectional levels along with existing alignment, realignments, cross roads, intersections and streams. The topographical survey has carried out as per the scope of work and methodology which is adopted for project highway with data processing also has been discussed detail in this chapter.

5.2 SCOPE OF WORK AND METHODOLOGY

The carrying out of topographic surveys it is one of the most important and crucial field tasks under the project. The detailed field survey has carried out using high precision instruments i.e. Total stations. The data from the topographic surveys is available in (x, y, z) format for use in a sophisticated digital terrain model (DTM).

The essential activities for detailed survey which had carried out are as follows:

Topographic Surveys along the Proposed Right of Way (ROW): Running a continuous Traverse along the project road corridors and fixation of a pair primary horizontal control stations at every 5 km interval with GPS. Closed traverse from one GPS to Other GPS has made by establishing permanent traverse stations at every 250m interval. Closed Loop Leveling has undertaken along the project corridor with a connection to nearest GTS station. All the horizontal control stations established at 250m has been connected with leveling.

- Topographic Surveys along the Existing Right of Way (ROW): Running a continuous open Traverse along the existing road, at bypass and realignments wherever required, and fixation of all cardinal points such as horizontal intersection points (HIP's), center points and transit points etc. and properly referencing the same with a pair of reference pillars fixed on either side of the centre-line at safe places within the ROW.

- Details collected for all features such as median, carriageway, paved shoulders, earthen shoulders, structures (bridges, culverts etc.), retaining structures edges/offset & levels, anti-crash barriers, railings, drains; edges of the drains with invert & top levels, utilities, existing service roads, cross roads, cart tracks, electric and telephone installations (both O/H as well as underground), huts, buildings, wells, shops, fencing etc. falling within the extent of survey
- Surveys of trees were covered girth wise (0-300mm, 300mm-600mm, 600mm-900mm, 900mm-1200mm >1200 mm & species wise with suitable nomenclature.
- Survey of utilities had carried out by mentioning ownership, dia/voltage, vertical clearance available above existing road level of electric line, transformer details, details of underground lines such as OFC, gas, etc.
- In case of existing drainage lines, top & invert level along with width & typical cross section details have shown in drawings.

The width of survey corridor will generally be as given under:

- The width of the survey corridor has taken into account the layout of the existing alignment including the extent of embankment and cut slopes and the general ground profile. While carrying out the field surveys, the widening scheme (i.e. right, left or symmetrical to the centre line of the existing carriageway) were taken into consideration so that the topographic surveys cover sufficient width beyond the centre line of the proposed carriageway. The field/khasra boundaries have also provided along with the survey data. The survey has extended a minimum 30m on either side of the centre line of the existing carriageway.
- The Survey along the existing NH-927D has done for about 105 km excluding bypass & realignment length. Survey for the bypass and realignment shall be done separately after finalization of alignment.
- Where existing roads cross the alignments, the survey has extended a minimum distance of 100m and 300m on either side of the NH -927D along the cross road centre line for the minor junction and major junction respectively.
- Where a bypass at congested location is proposed, surveyor has established traverse points for the proposed bypass location. The survey for the bypass & realignment were done after verification of alignment at site.
- Bench Mark / Reference pillar of size 15 cm X 15 cm X 45 cm has casted in RCC of

grade M 15 with a nail fixed in the centre of the top surface. The reference pillar has embedded in concrete up to a depth of 30cm with CC M10 (50mm wide all around). The balance 15cm above ground has painted yellow. The spacing 250m apart has adopted, incase Bench Mark Pillar coincides with Reference Pillar, only one of the two has provided.

- GPS pillar has fixed at every 5 km. of size 300 mm x 300 mm x 900 mm in RCC of grade M15. The pillars has embedded 600 mm in ground with CC M10 grade (50 mm wide all around). The balance 300 mm above ground has painted yellow and pillar no. marked on it.
- Wherever there is a proposal of realignment of the existing Highway and/or construction of New Bypasses, boundary pillars has fixed along the proposed alignment on the extreme boundary on either side of the project Highway at 50m interval.
- In addition to this, Chainage marking with yellow paint has carried out at an interval of 50m on the Carriageway.
- Establishing Benchmarks at site connected to GTS Bench marks at an interval of 250 meters on Bench mark pillar made of RCC as mentioned above with RL and BM No. marked on it with red paint.
- For the Bypass traverse benchmark pillars has established on proposed centerline at 250m interval.
- Additional reference points and bench marks has kept on all the existing structures such as Underpass, Flyovers, ROB and Culverts etc. along the Highway.

Longitudinal and Cross-Sections

The topographic surveys for longitudinal and cross-sections has covered as following:

- Longitudinal section levels has taken along final centre line at every 25m interval in straight section, 10m apart on vertical & horizontal curves, the locations of curve points, small streams, and intersections and at the locations of change in elevation.
- Cross sections level has taken at every 50m interval in straight sections and 25m interval at curves in full extent of survey covering sufficient number of spot levels on existing carriageway and adjacent ground for profile correction course and earthwork calculations.

- The Cross sectional levels has taken at 0 m, 0.5 m, 2 m, 3.5 m, 4.5 m, 6m & at every 2m till upto the toe point and at every 3 m thereafter on either side of centre line of existing road upto 30 m on either side. All the edge points at the change of slope such as edge of formation, toe, etc. has also be taken. The points of levels adjusted as per location of edge of Carriageway, Paved Shoulder, Earthen Shoulder, Toe of Embankment, Top of Drain, Invert of Drain etc. Levels along bypass shall be taken after finalization
- Invert level/ Bed level of all the culverts, Minor Bridges, Major Bridges, Rail top levels for ROBs has taken on u/s, d/s including road formation level at left, centre and right edge and same has tabulated separately for each structure with the reference number as marked at the site.
- Longitudinal Section of all Minor & Major Bridges along the stream has taken at 10m interval upto a distance of 300 m on Up Stream & Down Stream for Minor Bridges and upto a distance 500m on Up Stream & Down Stream for Major Bridges.
- Three Cross-sections across the stream has taken at 10m, 150m & 300m on both Up Stream and Down Stream for Minor Bridges and 20m, 150m, 300m & 500m for Major Bridges with respect to centre line of Bridge. The level has taken at 2 m interval for bridge of length upto 60 m and at 5 m interval for bridges of more than 60 m and has taken upto the sufficient extent in the approaches of the bridge

An open traverse could lead to cumulative errors of angles. Hence, at every 10 km the traverse has closed to limit cumulative errors. The benchmarks has referenced to GTS BM of the Survey of India. The ground cross-sections and details of features has referred to the BM. Separate teams concurrently with the traverse team has carried out these tasks. The leveling of the longitudinal section along the final centre line (FCL) and fixation of cardinal points has carried out after the approval of the alignment/Final Center line by IAHE.

The value of GTS Benchmark has been taken from **Bhadar Dam 52.0m.**



Figure 5.1: GTS Benchmark at Bhadar Dam

Table 5.1: List of GPS with Locations

Northing	Easting	Elevation (m)	Existing Km	Side	Distance From Ex.Cl. (Meter)	Remark
2452277.407	642697.523	113.655	51+830	LHS	21.580	
2456876.197	642427.352	87.624	46+940	LHS	21.200	
2457077.014	642446.287	91.859	45+740	LHS	10.000	
2460017.168	639372.348	101.106	42+160	RHS	26.500	
2460141.325	639274.661	99.870	42+000	RHS	43.600	
2463870.028	636378.189	82.523	37+000	RHS	29.170	
2463977.415	636305.559	81.314	36+970	RHS	65.000	
2467123.677	633560.232	89.363	32+110	LHS	16.700	
2467261.612	633527.029	91.607	31+970	LHS	22.700	
2469778.223	629887.469	73.721	27+245	RHS	16.640	
2469800.361	629731.988	72.956	27+070	RHS	16.800	
2473280.063	626577.280	59.121	22+000	RHS	17.800	
2473474.253	626567.059	54.295	21+810	RHS	22.660	
2477062.530	625188.574	55.313	17+283	LHS	38.400	
2476964.072	625383.426	55.248	17+067	LHS	15.030	
2479011.345	621307.396	37.552	11+960	LHS	28.650	
2479207.579	621161.553	33.574	11+715	LHS	19.270	
2481579.870	617376.664	22.096	7+215	RHS	28.560	
2481685.820	617145.097	22.008	6+960	RHS	27.500	
2482743.590	615109.286	20.146	SH-25	RHS	88.000	End Point of Project towards Morbi
2482595.754	614990.677	21.230	SH-25	LHS	100.000	End Point of Project towards Dwarka

Table 5.2: List of TBM Pillars

BMP	Easting	Northing	Elevation (m)	Existing Km	Side	Distance From Ex. Cl. (Meter)
BMP51/1	643067.827	2452960.569	104.773	51+000	RHS	14.5
BMP50/4	643070.689	2453219.067	103.818	50+750	RHS	17.5
BMP50/3	643043.560	2453471.020	103.016	50+495	RHS	18
BMP50/2	643016.313	2453717.441	102.409	50+250	RHS	17
BMP50/1	642977.391	2453964.569	101.386	50+000	RHS	4.5
BMP49/4	642875.175	2454213.353	99.721	49+740	RHS	8
BMP49/3	642774.608	2454441.593	100.181	49+490	RHS	6.5
BMP49/2	642687.578	2454650.033	98.979	49+260	RHS	9.5
BMP49/1	642593.419	2454892.472	98.192	49+000	LHS	9.5
BMP48/4	642640.805	2455121.589	97.789	48+770	RHS	14.5
BMP48/3	642650.297	2455376.119	97.148	48+520	RHS	13
BMP48/2	642533.669	2455601.701	96.305	48+270	LHS	9
BMP47/4	642480.959	2456074.986	94.085	47+730	RHS	14.5
BMP46/3	642573.964	2457209.761	88.742	47+500	LHS	16.5
BMP46/2	642339.711	2457292.163	88.682	47+250	LHS	10
BMP46/1	642103.427	2457376.830	92.601	47+000	LHS	11
BMP45/4	641922.506	2457530.520	95.041	46+765	RHS	22.5
BMP45/3	641715.355	2457672.382	95.944	46+495	RHS	18.5
BMP45/2	641518.006	2457810.292	98.306	46+260	RHS	15.5
BMP45/1	641313.304	2457962.156	98.473	45+000	RHS	17
BMP44/4	641112.282	2458119.242	101.232	44+740	RHS	17
BMP44/3	640953.137	2458309.774	102.021	44+495	RHS	20
BMP44/2	640786.192	2458494.250	108.253	44+245	RHS	15
BMP44/1	640594.711	2458648.039	109.453	44+000	RHS	21
BMP43/4	640384.465	2458816.517	110.217	43+725	RHS	25

BMP	Easting	Northing	Elevation (m)	Existing Km	Side	Distance From Ex. Cl. (Meter)
BMP43/3	640202.834	2458982.320	108.667	43+495	RHS	22.5
BMP43/2	640019.894	2459142.689	106.566	43+250	RHS	15.5
BMP43/1	639873.717	2459335.539	105.443	43+000	RHS	15.5
BMP42/4	639728.409	2459552.435	104.053	42+745	RHS	6
BMP42/3	639596.814	2459771.221	101.641	42+490	RHS	10.5
BMP42/2	639419.045	2459949.992	100.034	42+250	RHS	10
BMP42/1	639253.571	2460114.443	99.512	42+000	RHS	9.5
BMP41/4	639097.402	2460294.771	97.24	41+765	RHS	10.5
BMP41/3	638926.801	2460479.288	96.533	41+500	LHS	11
BMP41/2	638787.332	2460684.666	94.968	41+320	LHS	8.5
BMP41/1	638633.160	2460870.436	94.358	41+010	RHS	11.5
BMP40/4	638399.305	2461028.878	92.208	40+740	LHS	11.5
BMP40/3	638271.886	2461233.284	91.722	40+495	RHS	9
BMP40/2	638151.911	2461466.922	90.745	40+235	RHS	10
BMP40/1	638078.109	2461687.572	88.686	40+000	RHS	9
BMP39/4	637984.335	2461930.387	88.863	39+745	LHS	7.5
BMP39/3	637933.260	2462179.696	85.223	39+495	RHS	16
BMP39/2	637838.303	2462424.526	85.684	39+235	RHS	12
BMP39/1	637739.333	2462633.793	85.003	39+000	RHS	9
BMP38/4	637616.350	2462849.007	84.997	38+750	RHS	8.5
BMP38/3	637422.788	2463005.226	83.236	38+495	RHS	9
BMP38/2	637312.917	2463226.277	83.501	38+250	RHS	13
BMP38/1	637112.239	2463358.698	82.933	38+000	LHS	9.5
BMP37/4	636884.350	2463478.886	83.706	37+750	LHS	11
BMP37/3	636653.618	2463600.668	83.258	37+490	LHS	10.5
BMP37/2	636472.932	2463768.889	81.701	37+240	RHS	12

BMP	Easting	Northing	Elevation (m)	Existing Km	Side	Distance From Ex. Cl. (Meter)
BMP37/1	636283.186	2463923.809	81.324	37+000	RHS	9.5
BMP36/4	636087.189	2464088.671	82.465	36+755	RHS	8
BMP36/3	635905.649	2464264.230	83.92	36+505	RHS	9
BMP36/2	635727.955	2464417.901	79.355	36+240	RHS	7
BMP36/1	635482.781	2464373.577	80.642	36+010	RHS	9.5
BMP35/4	635245.092	2464288.250	82.931	35+750	LHS	8
BMP35/3	635002.154	2464275.149	83.074	35+500	RHS	5
BMP35/2	634885.228	2464476.645	82.072	35+250	LHS	16
BMP35/1	634837.524	2464719.373	84.01	35+000	LHS	10
BMP34/4	634873.856	2464980.946	84.451	34+745	RHS	8
BMP34/3	634925.608	2465211.076	85.534	34+500	RHS	12.5
BMP34/2	634746.912	2465398.836	86.417	34+250	LHS	8.5
BMP34/1	634602.424	2465602.926	87.619	34+000	RHS	6.5
BMP33/4	634443.859	2465817.561	87.303	33+730	RHS	7
BMP33/3	634276.608	2466014.467	86.474	33+500	RHS	7
BMP33/2	634116.138	2466194.115	85.731	33+240	RHS	10.5
BMP33/1	633910.114	2466349.656	87.066	32+995	LHS	15.5
BMP32/4	633743.549	2466521.169	89.566	32+755	RHS	9
BMP32/3	633668.094	2466758.627	90.612	32+490	RHS	14
BMP32/2	633610.084	2466997.199	88.33	32+250	RHS	6
BMP32/1	633574.068	2467234.702	91.298	32+005	RHS	18
BMP31/4	633510.089	2467510.070	89.714	31+725	RHS	10.5
BMP31/3	633364.298	2467697.668	90.325	31+500	RHS	18.5
BMP31/2	633136.284	2467809.532	94.583	31+250	LHS	15
BMP31/1	633009.552	2468013.604	92.85	31+000	RHS	21.5
BMP30/4	632848.968	2468215.794	90.012	30+745	RHS	9.5

BMP	Easting	Northing	Elevation (m)	Existing Km	Side	Distance From Ex. Cl. (Meter)
BMP30/2	632531.210	2468597.742	80.497	30+250	RHS	7.5
BMP30/1	632336.110	2468757.582	78.393	30+000	RHS	11
BMP29/4	632169.191	2468941.111	76.67	29+750	RHS	6.5
BMP29/3	631975.897	2469103.284	75.105	29+500	LHS	9.5
BMP29/2	631304.541	2469204.526	66.101	29+250	RHS	19.5
BMP29/1	631532.254	2469229.519	69.362	29+000	RHS	6.5
BMP28/4	631779.205	2469244.281	73.582	28+760	RHS	7.5
BMP28/3	631104.659	2469330.283	66.861	28+500	RHS	6.5
BMP28/2	630882.290	2469451.460	66.451	28+250	RHS	9
BMP28/1	630637.840	2469541.523	69.727	27+990	RHS	7.5
BMP27/4	630385.713	2469642.009	72.33	27+720	RHS	15.5
BMP27/3	630146.427	2469728.042	76.787	27+500	RHS	11.5
BMP27/2	629903.445	2469767.903	75.216	27+250	RHS	8.5
BMP27/1	629656.747	2469782.830	74.716	27+000	LHS	11
BMP26/4	629370.629	2469846.193	78.011	26+710	RHS	11.5
BMP26/3	629125.512	2469880.213	81.409	26+500	RHS	11.5
BMP26/2	628951.164	2470014.986	80.797	26+250	RHS	9
BMP26/1	628801.770	2470217.428	80.415	26+000	RHS	16
BMP25/4	628728.111	2470312.425	81.455	25+880	RHS	7
BMP25/3	628614.053	2470532.022	76.038	25+630	RHS	6.5
BMP25/2	628499.673	2470752.937	74.885	25+250	RHS	7.5
BMP25/1	628347.391	2470944.266	71.807	25+005	RHS	7.5
BMP24/4	628172.802	2471143.418	71.446	24+740	RHS	9.5
BMP24/3	627993.097	2471314.065	68.966	24+500	LHS	12.5
BMP24/2	627846.861	2471516.168	70.699	24+250	RHS	8.5
BMP24/1	627694.216	2471716.642	72.238	24+000	RHS	9.5

BMP	Easting	Northing	Elevation (m)	Existing Km	Side	Distance From Ex. Cl. (Meter)
BMP23/4	627522.187	2471900.593	67.26	23+750	LHS	14
BMP23/3	627352.286	2472080.894	63.955	23+500	RHS	14
BMP23/2	627172.546	2472243.158	61.933	23+250	RHS	15
BMP23/1	626991.804	2472406.008	65.814	23+000	RHS	11.5
BMP22/4	626793.089	2472596.097	64.853	22+730	RHS	10.5
BMP22/3	626685.475	2472820.408	60.979	22+500	RHS	11.5
BMP22/2	626564.690	2473040.414	61.811	22+250	LHS	14
BMP22/1	626551.148	2473277.980	59.418	22+000	LHS	8
BMP21/4	626531.801	2473534.831	53.843	21+750	LHS	7.5
BMP21/3	626505.376	2473780.035	58.446	21+500	LHS	15
BMP21/2	626418.245	2474002.911	57.572	21+250	LHS	12
BMP21/1	626280.832	2474214.139	65.695	21+000	LHS	7
BMP20/4	626288.046	2474451.796	71.077	20+760	LHS	8.5
BMP20/3	626357.242	2474704.516	63.174	20+500	RHS	4
BMP20/2	626415.080	2474932.959	58.868	20+250	RHS	12.5
BMP20/1	626453.340	2475173.060	60.041	20+000	RHS	7
BMP19/4	626436.359	2475419.239	55.213	19+745	LHS	8.5
BMP19/3	626421.135	2475660.672	53.329	19+485	LHS	9
BMP19/2	626422.089	2475901.725	54.049	19+215	RHS	6
BMP19/1	626405.364	2476156.679	53.129	19+000	RHS	6
BMP18/4	626390.291	2476407.315	50.22	18+750	RHS	6
BMP18/3	626308.318	2476640.639	48.069	18+500	RHS	6.5
BMP18/2	626163.778	2476843.928	43.676	18+250	LHS	5.5
BMP18/1	626046.812	2477056.559	40.636	18+000	RHS	9.5
BMP17/4	625823.905	2477127.465	41.569	17+755	LHS	6.5
BMP17/3	625582.606	2477159.472	45.782	17+500	RHS	4.5

BMP	Easting	Northing	Elevation (m)	Existing Km	Side	Distance From Ex. Cl. (Meter)
BMP17/2	625357.119	2477083.858	54.079	17+260	LHS	6.5
BMP17/1	625130.141	2476953.743	55.122	17+000	RHS	7.5
BMP16/4	624923.740	2476805.169	56.06	16+760	LHS	6.5
BMP16/3	624693.530	2476689.885	59.245	16+500	RHS	9.5
BMP16/2	624459.325	2476713.646	58.506	16+250	LHS	15.5
BMP16/1	624299.515	2476912.507	55.373	16+000	LHS	10
BMP15/4	624158.275	2477117.906	55.899	15+745	RHS	8.5
BMP15/3	623968.859	2477291.459	54.541	15+500	RHS	8.5
BMP15/2	623735.852	2477349.419	48.066	15+250	LHS	9
BMP15/1	623484.790	2477442.040	46.519	14+990	RHS	5.5
BMP14/4	623249.438	2477520.382	47.766	14+735	RHS	9
BMP14/3	623019.714	2477588.921	49.175	14+500	RHS	7.5
BMP14/2	622793.734	2477686.025	47.764	14+250	RHS	10.5
BMP14/1	622619.676	2477846.637	45.368	14+015	RHS	6
BMP13/4	622495.436	2478060.059	43.206	13+730	RHS	7.5
BMP13/3	622286.980	2478194.443	43.363	13+495	RHS	6
BMP13/2	622219.866	2478386.154	38.945	13+245	RHS	7.5
BMP13/1	621984.525	2478418.895	35.889	13+000	LHS	12.5
BMP12/4	621833.615	2478603.222	34.805	12+750	RHS	6.5
BMP12/3	621697.252	2478752.016	31.102	12+540	RHS	12.8
BMP12/2	621483.832	2478788.420	38.5	12+270	RHS	19
BMP12/1	621349.429	2479014.164	37.734	12+000	RHS	7
BMP11/4	621199.178	2479219.583	34.174	11+775	RHS	17
BMP11/3	620984.215	2479358.271	33.864	11+525	RHS	6
BMP11/2	620776.839	2479506.191	32.102	11+250	RHS	17
BMP11/1	620559.823	2479618.382	31.012	11+000	RHS	9

BMP	Easting	Northing	Elevation (m)	Existing Km	Side	Distance From Ex. Cl. (Meter)
BMP10/4	620358.717	2479694.102	31.874	10+785	RHS	7.5
BMP10/3	620157.276	2479833.505	31.77	10+500	RHS	6.5
BMP10/2	619952.893	2479979.173	30.628	10+250	RHS	7
BMP10/1	619748.754	2480127.432	29.409	10+000	RHS	10
BMP9/4	619560.822	2480245.722	28.63	9+775	RHS	15
BMP9/3	619343.242	2480372.344	27.246	9+525	RHS	12
BMP9/2	619134.279	2480494.846	25.872	9+255	RHS	9
BMP9/1	618906.081	2480604.930	24.11	9+000	LHS	13.5
BMP8/4	618699.260	2480758.684	24.506	8+750	RHS	11.5
BMP8/3	618485.718	2480883.837	25.144	8+500	RHS	9
BMP8/2	618273.454	2481018.454	25.07	8+250	RHS	15
BMP8/1	618066.416	2481152.027	23.809	8+000	RHS	12
BMP7/4	617832.750	2481319.006	22.967	7+710	RHS	11
BMP7/3	617619.044	2481446.223	22.659	7+500	RHS	9
BMP7/2	617406.264	2481549.888	21.707	7+260	RHS	14
BMP7/1	617167.530	2481652.641	21.921	7+000	RHS	6.5
BMP6/4	616967.299	2481798.854	20.781	6+745	RHS	7
BMP6/3	616782.442	2481975.320	19.336	6+500	RHS	19.5
BMP6/2	616548.590	2482051.903	21.433	6+250	RHS	12
BMP6/1	616310.428	2482142.140	19.908	6+000	RHS	17
BMP5/4	616064.370	2482223.744	20.049	5+740	RHS	10.5
BMP5/3	615833.441	2482307.203	19.276	5+495	RHS	11
BMP5/2	615605.571	2482387.622	19.287	5+250	RHS	9.5
BMP5/1	615369.592	2482484.435	18.394	5+000	RHS	16
BMP4/4	615173.615	2482614.624	18.784	4+765	RHS	17.5
BMP4/3	615064.457	2482687.861	20.414	4+635	RHS	17

The readings from the Total Stations were available in (x, y, z) format using data base software and then transferred to the survey model of the MX Road or any other suitable Software to prepare the DTM of the area surveyed. The DTM and the longitudinal profile of the FCL has computed by the software and drawn using Auto CAD on A2/A3 size sheets showing 0.5 km sections in 1:1000 scale and the vertical using 1:100 for mountainous / steep terrain. For difficult locations such as steep terrain, hair pin bend etc, plan has drawn using higher scale. For Plain / rolling terrain scale has taken as 1:2500.

For sharp curves, additional areas (ground sections, topographical features and utilities) has surveyed as required. During this Survey, all utilities within the areas surveyed has identified, and noted; complementary data has collected from the competent bodies to complete the picture.

Where existing roads cross the alignments, the survey has extended a minimum of 100 m either side of the road centre line and will be of sufficient width to allow improvements, including at grade intersection to be designed.

The final location survey has transferred the selected alignment to the ground by fixing reference pillars at 250 m intervals. Benchmarks has established at intervals of 250 m.

5.3 GENERAL TERRAIN

Approximately 5% road passes through rolling terrain, about 95% in plain terrain The project is to be developed with appropriate measures to provide access to all having access at the present taking into consideration the type of terrain. The design of geometric elements will, therefore, take into account the essential requirements of such facilities.

5.4 FEATURE CODES

Table 5.3: Feature Codes

S. No.	Feature	String Name	AUTOCAD Feature Layer Name
1	200m stone	HMP	EX-200-STONE
2	Buildings (Kaccha)	BGK	EX-BUILDINGS KACHHA
3	Buildings (Pucca)	BGP	EX-BUILDINGS PUCCA
4	Bus Stand	BS	EX-BUS-STAND
5	Bushes	BUSH	EX-BUSHES
6	Carriageway (Earthen Shoulder)	CES	EX-CARRIAGEWAY-ES
7	Carriageway (Lanes)	CLN	EX-CARRIAGEWAY-LANES

S. No.	Feature	String Name	AUTOCAD Feature Layer Name
8	Carriageway (Median Edge)	CME	EX-CARRIAGEWAY-MEDIANEDGE
9	Carriageway (Paved Shoulder)	CPS	EX-CARRIAGEWAY-PAVED SHOULDER
10	Centerlines	CL	EX-CENTRELINE
11	RCC Crash Barriers	RCB	EX-RCC CRASH-BARRIERS
12	W Beam Crash Barriers	WCB	EX-W BEAM CRASH BEARRIER
13	Cross Road Edge (BT)	CRB	EX-CROSS_ROAD_EDGE_BT
14	Cross Road Edge (ES)	CRE	EX-CROSS_ROAD_EDGE_ES
15	Drain Bottom (Concrete)	DBC	EX-DRAIN-BC
16	Drain Bottom (Earthen)	DBE	EX-DRAIN-BE
17	Drain Top (Concrete)	DTC	EX-DRAIN-TC
18	Drain Top (Earthen)	DTE	EX-DRAIN-TE
19	Drain Chamber Top Level	DCT	EX-DRAIN -CT
20	Drain Chamber Bottom Level	DCB	EX-DRAIN -CB
21	Earthworks (Bund)	EB	EX-EARTHWORK-BUND
22	Earthworks (Cut)	EC	EX-EARTHWORK-CUT
23	Earthworks (Fill)	EF	EX-EARTHWORK-FILL
24	Edge Stone	EST	EX-EDGE STONE
25	Electric Poles	EP	EX-UTILITY-EP
26	Electric Substation/transformer	ESB	EX-UTILITY-ESB
27	Fences	FNS	EX-FENCE
28	Gas Line	GAS	EX-UTILITY-GAS
29	Gas/Water Stop valves	GV	EX-GAS/WATER STOP VALVES
30	Gates	G	EX-GATES
31	GPS Pillar	GPS	EX-GPS
32	Hand Railing	HR	EX-HANDRAIL
33	High Tension Electric Line	HT	EX-UTILITY-HT
34	Hoardings	HRD	EX-HOARDINGS

S. No.	Feature	String Name	AUTOCAD Feature Layer Name
35	Industry/ Factory	IF	EX-INDUSTRY-FACTORY
36	Kerb Bottom	KB	EX-KERB BOTTOM
37	Kerb Top	KT	EX-KERB TOP
38	KM Stone	KMS	EX-KM-STONE
39	Low Tension Electric Line	LT	EX-UTILITY-LT
40	Manhole	MH	EX-UTILITY-MANHOLE
41	Optical Fiber Cable	OFC	EX-UTILITY-OFC
42	Pond / Lake	PND	EX-POND/LAKE
43	Pylon	PY	EX-PYLON
44	Reference Pillar	RP	EX-RP
45	Religious Structure (Temple etc.)	RST	EX-RELIGIOUS-STRUCTURE
46	Road Boundary	RB	EX-ROAD BOUNDARY
47	Road Furniture	RF	EX-ROAD FURNITURE
48	Road Signs	RS	EX-ROAD SIGNS
49	School, College	SC	EX-SCHOOL-COLLEGE
50	Service Road BT Edge	SRB	EX-SR-BT EDGE
51	Service Road Centerline	SRC	EX-SR-CENTERLINE
52	Service Road Earthen Shoulder	SRE	EX-SR-EARTHEN SHOULDER
53	Sewer Line	SL	EX-UTILITY-SEWER
54	Shrubs	SHR	EX-SHRUBS
55	Spot levels	L	EX-SPOT LEVELS
56	Stone Pitching	SP	EX-STONE-PITCHING
57	Telephone call box	TCB	EX-TELEPHONE CALL BOX
58	Telephone Pole	TP	EX-UTILITY-TP
59	Temporary Benchmark	TBM	EX-TBM
60	Temporary Building or structures	TBL	EX-TEMP-BUILDING
61	Tower	TOW	EX-UTILITY-TOWER

S. No.	Feature	String Name	AUTOCAD Feature Layer Name
62	Traffic Islands (TL)	TL	EX-TRAFFIC ISLANDS (TL)
63	Traffic Signals	TS	EX-TRAFFIC SIGNALS
64	Trees (Species-1- 0 to 300 mm)	T1	EX-T1
65	Trees (Species-2-300 to 600 mm)	T2	EX-T2
66	Trees (Species-3-600 to 900 mm)	T3	EX-T3
67	Trees (Species-4-900to1200 mm)	T4	EX-T4
68	Trees (Species-5 ->1200 mm)	T5	EX-T5
69	Verges Footpaths and Tracks	V	EX-VERGES FOOTPATHS AND TRACKS
70	Walls	W	EX-WALLS (Boundary & Compound wall)
71	Pipe Culvert (Single)	PC-1	EX-SINGLE PIPE CULVERT
72	Pipe Culvert (Double)	PC-2	EX-DOUBLE PIPE CULVERT
73	Pipe Culvert (Triple)	PC-3	EX-TRIPLE PIPE CULVERT
74	Pipe Culvert (Multi)	PC-M	EX-MULTI PIPE CULVERT (MENTION VALUE OF 'M')
75	Invert Level	INV	EX-Pipe dia bottom level/ Box bottom level
76	Pipe Top Level	PITL	EX-Pipe dia Top level
77	Head Wall	HL	EX-Head Wall
78	Box Culvert (Single Cell)	BC-1	EX-Single Cell Box Culvert
79	Box Culvert (Double Cell)	BC-2	EX-Double Cell Box Culvert
80	Box Culvert (Triple Cell)	BC-3	EX-Triple Cell Box Culvert
81	Box Culvert (Multi Cell)	BC-M	EX-MULTI Cell Box CULVERT (MENTION VALUE OF 'M')
82	Slab Culvert	SLC	EX-Slab Culvert
83	Arch Top Level	ARCH-T	EX- ARCH TOP
84	Arch Bottom Level (RHS)	ARCH-R	EX- ARCH BOTTOM RHS
85	Arch Bottom Level (LHS)	ARCH-L	EX- ARCH BOTTOM LHS
86	Lined Irrigation Canal	IC-L	EX-IRRIGATION-CANAL (Lined)

S. No.	Feature	String Name	AUTOCAD Feature Layer Name
87	Unlined Irrigation Canal	IC-U	EX-IRRIGATION-CANAL (Unlined)
88	Bridge	BR	EX-Bridge
89	Abutment	ABT	EX-ABUTMENT
90	Abutment Cap Top Level	ABT CAPL	EX-Abutment Cap top level
91	Abutment Bed Level	A-BL	EX-Bed level at location of Abutment
92	Abutment Top Face1	ABT 1	EX-Abutment Top Face1
93	Abutment Top Face2	ABT 2	EX-Abutment Top Face2
94	Abutment Bottom Face1	ABB 1	EX-Abutment Bottom Face1
95	Abutment Bottom Face12	ABB 2	EX-Abutment Bottom Face12
96	Pier Top 1 st Face Level	PRT 1	EX-Pier Top 1 st Face
97	Pier Top 2 nd Face Level	PRT 2	EX-Pier Top 2 nd Face
98	Pier Bottom 1 st Face Level	PRB 1	EX-Pier Bottom 1 st Face
99	Pier Bottom 2 nd Face Level	PRB 2	EX-Pier Bottom 2 nd Face
100	Pier	PR	EX-PIER
101	Pier Cap Top Level	PR-TC	EX-Pier Cap Top Level
102	Pier Bed Level	P-BL	EX-Bed level at location of Pier
103	Footpath	FP	EX-FOOTPATH
104	Railing top Level	RTL	EX-Railing top Level
105	Railing Bottom Level	RBL	EX-Railing Bottom Level
106	Flow Direction	←	EX-Flow
107	Nallah/ River/Canal Bed Level	BL	EX-Nallah/ River/Canal Bed Level
108	Ground Level	GL	EX-Ground Level of Approaches & Surroundings
109	Wing Wall Top	WWT	EX-Wing Wall TOP
110	Wing Wall Bottom	WWB	EX-Wing Wall BOTTOM
111	High Flood Level	HFL	EX-HFL
112	Structure Soffit Level	SFL	EX-Structure Soffit Level

S. No.	Feature	String Name	AUTOCAD Feature Layer Name
113	Retaining wall, Top	RWT	EX-RW-TOP
114	Retaining wall, base	RWB	EX-RW-BOTTOM
115	Parapet top Level	PTL	EX-Parapet top Level
116	Parapet Bottom Level	PBL	EX-Parapet Bottom Level
117	Nallah/River/Canal, Top of bank	DRT	EX-RIVER-TOP
118	Flyover	FLY	EX-FLYOVER
119	Vehicular Underpass	VUP	EX-VUP
120	Pedestrian Underpass	PUP	EX-PUP
121	Cattel Underpass	CUP	EX-Cattel Underpass
122	Road over Bridge (ROB)	ROB	EX-Road over Bridge (ROB)
123	Railway Track	RT	EX-RAIL
124	Railway Boundary	RTB	EX-Railway Boundary
125	Railway KM / EP / TP	RKM	EX-Railway KM / EP / TP
126	Bus Bays	BBS	EX-Bus Bays/Bus Shelter
127	Truck Lay Bys	TLB	EX-Truck Lay Bys
128	Pedestrian Guard Rail	PGL	EX-Pedestrian Guard Rail
129	Dhabhas	DBS	EX-Dhabhas
130	Hotel/Restaurant	HRT	EX-Hotel/Restaurant
131	Filling Station	PP	EX-Filling Station/petrol Pump
132	Hospital/Dispensary/ medical	HMD	EX-Hospital/Dispensary/medical
133	Stair	STL	Ex- Stair
134	Toll Plaza	TOL	Ex- Toll Plaza
135	Grave Yard	GYD	Ex- Funeral/Shamshan Ghat
136	Drain Bottom Stone/ Brick	DBB	Ex-Stone/Brick Drain Bottom level
137	Drain Top Stone/Brick	DTB	Ex-Stone/Brick Drain Top level
138	Arch Culvert	ARC	Ex-Arch Culvert
139	Arch Edge Level	AEL	Ex-Arch Edge level

S. No.	Feature	String Name	AUTOCAD Feature Layer Name
140	Stone/Brick Retaining Wall, Top	RBT	Ex-Stone/Brick retaining Wall Top level
141	Stone/Brick Retaining Wall, Base	RBB	Ex-Stone/Brick retaining Wall Bottom level
142	Existing Right of Way	EROW	Ex-Right of Way (if some location easy to identify)
143	RE Wall	REW	Ex-RE Wall
144	Water Pipe Lines	WPL	Ex-Utility Water Pipe
145	Cart Track Level	CRT	EX- Cart Track

5.5 ROAD INVENTORY SURVEYS

To know the existing road characteristics in terms of its geometry, data on roadside land use, right of way, width of carriageway, junctions, road safety features, submergence and utilities were collected along road. The road inventory has been done from km 107+500 of SH-26 (old) at the Junction of NH-27 where grade separation by VUP is exist with SH-26 and NH-27 to end point at km 4+700 of SH-26. The Road Inventory Survey data are enclosed as **Appendix-5.1 (Volume-II, Part-II of Draft Feasibility Report)**.

The road inventory depicts the following. The existing road falls in plain terrain:

- The existing carriageway width observed generally of about 6 to 7 metres and 14 Meters at some locations.
- The shoulder width varies from 1.0 to 1.5 meters.
- Road side land use is mostly built-up area and agricultural land in adjoining plane section.
- Roadside drain is present at some locations.
- 7 major junctions and 16 minor junctions are present along the existing road.
- Project road is passing through two districts namely Jamnagar and Rajkot and Four Taluka places of Jamnagar, Kalavad, Jamkandorna and Dhoraji with following villages Theba, Vijarkhi, Modpar, Moti Matli, Khandhera, Haripar, Toda, Kanavadala, Satudad, Thordi, Boria, Riyadi, Vegadi.
- The existing project road has ROW varying from 24 to 30 meters.

5.6 BRIDGE & CULVERT INVENTORY SURVEY

A project team (comprised of a Bridge Engineer, a Hydrologist, a Geotechnical Engineer & supporting staff) carried out the bridge inventory surveys and visual condition survey of existing bridges as per guidelines stipulated in applicable codal provisions (IRC-SP: 19, 35 & 40). The project team inspected the existing Bridges & other cross Drainage Structures lying on the project road and recorded the data using Performa prepared for carrying out the detailed condition survey. The deficiencies in the existing structures were noted to ascertain the measures required for strengthening of the structure.

All the details stipulated in IRC codes for efficient detailed inventory & condition survey of structures has been tabulated in a convenient format enabling easy analysis. The cross drainage structures were identified based on the material of construction, carriageway width, total length, and type of structure.

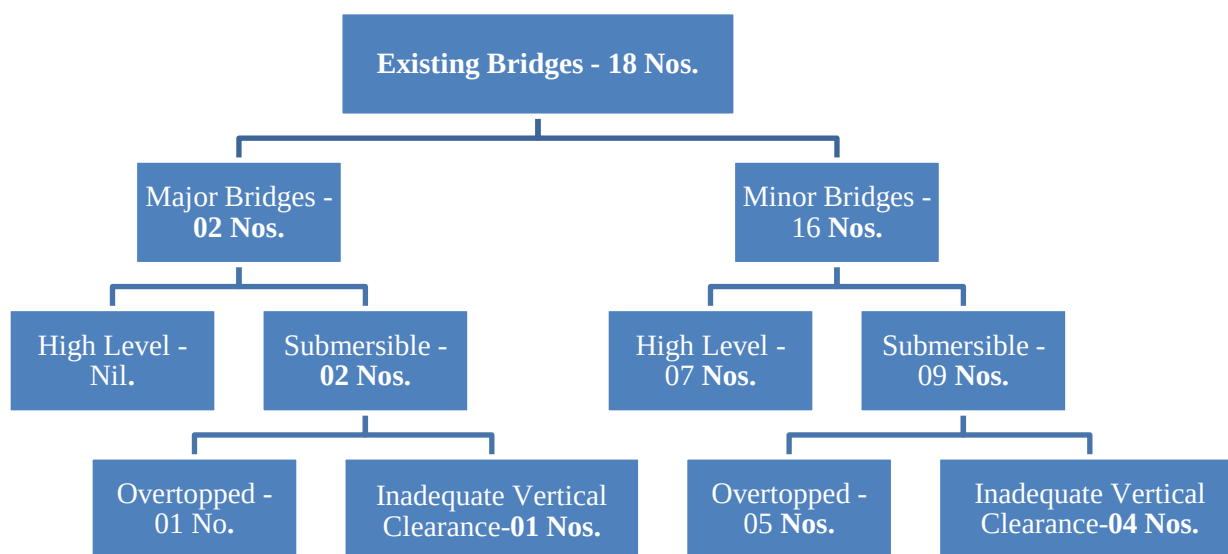


Figure 5.2: Details of Existing Bridges

The recorded data of Bridges (i.e. Inventory and Condition Surveys of Bridges) are enclosed in **Chapter-9 as Appendix-9.1 (Volume-II, Part-III of Draft Feasibility Report)**.

As per detailed Inventory & condition Survey of the Stretch, there are 02 Major Bridges, 16 Minor Bridges & 73 Culverts (including canal culverts) lying along the Project Stretch. Some common distresses observed were exposed and corroded reinforcement in slabs; spalling of concrete, damaged/missing railing and growth of vegetation on pier caps and in vent ways, damaged wearing coat, damaged expansion joints & settlement of embankment around abutments etc. Many of the Bridges were reported to be overtopped (lying in submersible

category), quite old, narrow, weak and in distressed condition. Some of the structures might require reconstruction due to submergence and poor condition. Details of existing structures are shown in **Figure 5.3 & Figure 5.4.**



Major Bridge at Km 46.270



Major Bridge at Km 35+625

Figure 5.3: Existing Bridges along the Project Road

The existing culverts observed along the project road are mainly of four types viz. RCC Slab culverts, Pipe culverts, Canal Culverts, and causeway. The structural condition of pipe culverts is generally fair, except few partially choked or buried culverts due to heavy vegetation. Most of the slab culverts are in poor condition. Some common distresses observed were damaged parapets, cracked/ damaged headwalls, abutments and return walls, corroded exposed reinforcement, insufficient waterway etc.

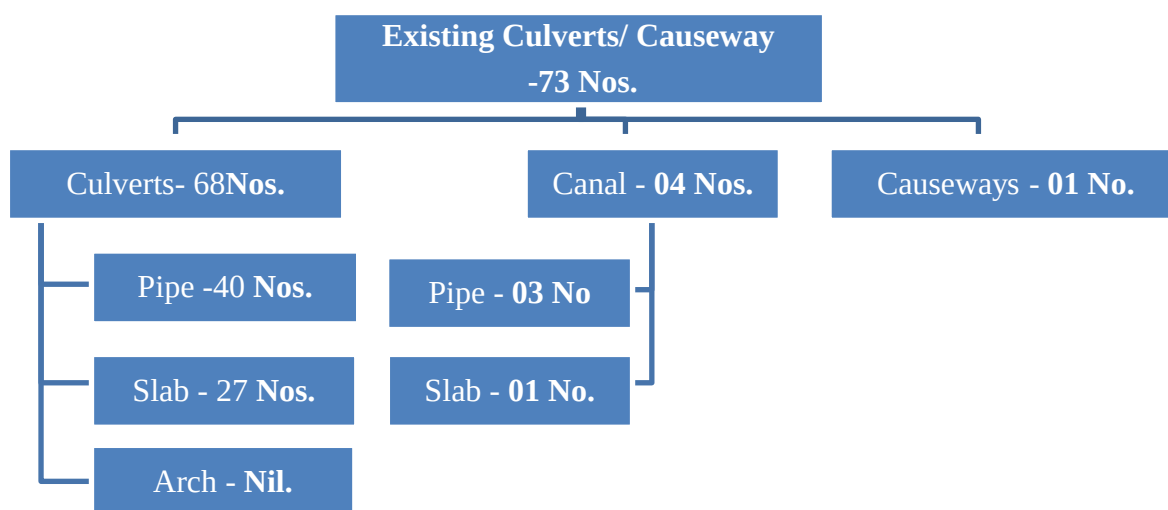


Figure 5.4: Details of Existing Culverts

The recorded data of Culverts (i.e. Inventory and Condition Surveys of Culverts) are enclosed **Chapter-9 as Appendix-9.2 (Volume-II, Part-III of Draft Feasibility Report).**

On the basis of the distresses observed in respect of various components of the structures (e.g. bearings, expansion joints, wearing coat railings/crash-barriers, foundation, substructures including abutments, piers, pier caps, superstructure) the structures are divided into the following categories:

- (i) Structures (that are Submersible or in poor condition) requiring reconstruction immediately.
- (ii) Structures treated as Vented Causeways requiring reconstruction as a High Level Bridge due to presence of flooded Water bodies on either sides;
- (iii) Structures requiring repairs and/or rehabilitation. Suitable repair/ rehabilitation measures will be suggested in respect of the existing structures as per IRC SP: 40 along with their specifications, drawings and cost estimate.
- (iv) Structures requiring widening. The existing structures having inadequate carriageway width will be widened/ reconstructed in part or full as per the latest guidelines in this regard and IRC-SP: 84-2019 (4 laning Manual for National Highways).
- (v) Structures that shall be retained.

5.6.1 Sub-soil Investigation

To evaluate the subsoil properties needed for the design of foundations, detailed geo-technical investigations will be conducted at all bridges, underpasses, embankment locations along the project road. The minimum scope followed for geo-technical investigations for bridges & other structures is as under:

Table 5.4: Borehole Location

S. No.	Description	Location of Boring
1	Overall Length = 6 to 30 m	One abutment location.
2	Overall Length = 30 to 60 m	One abutment location & at least one intermediate location between abutments for structures having more than one span.
3	Overall Length > 60 m	Each abutment and each pier locations.
4	For Vehicular Underpasses & other grades separated structures	One at Abutment location & four at approaches of the proposed structure (i.e. two on either side).
5	Pedestrian Underpass	One at Abutment location.

The depth of boring shall be conducted as per provision in IRC: 78-2014, MORTH specification. Proposed bore log location plan for Bridges shall be submitted separately, before commencement.

The Depth of bore-Logs is based on expected type of foundation. During execution of boring; as per the strata, if it seems open foundation is not suitable, the depth of bore may be increased suitably in view of other deeper foundation which shall be not less than:

- 1.5 times the estimated length of pile in soil but not less than 15.0m beyond the probable length of pile
- 15 times the diameter of pile in weak/ jointed rock but minimum of 15.0m in such rock.
- 4 times the diameter of pile in sound, hard rock; but minimum 3.0 m in such rock.

In case of open foundation, the bore hole shall be done as per IRC: 78 i.e. 1.5 times the width of the foundation below the proposed foundation level. The depth of drilling/ coring shall be 5.0m in soft rock 3.0m in hard rock.

5.7 PAVEMENT CONDITION SURVEY & INVESTIGATION

5.7.1 Introduction

The surface condition of the road pavement, shoulders and embankment is ascertained by carrying out physical inspection. These observations are tabulated and presented in the formats prescribed for recording data that were collected during pavement condition survey, carried out in the month of July, 2015. The Pavement Condition Survey & Investigation data are enclosed as **Appendix-5.2 (Volume-II, Part-II of Draft Feasibility Report)**.

Based on the extent of deteriorations observed during survey, the project road can be divided into following sections represented as pie charts.

Table 5.5: Length Wise Pavement Composition

Pavement condition is good		Length	Pavement condition is fair		length	Pavement condition is poor		Length
4+700	8+800	4.100	8+800	9+400	0.600	15+000	16+000	1.000
9+400	15+000	5.600	23+000	24+400	1.400	28+000	29+200	1.200
16+000	23+000	7.000	60+600	64+000	3.400	35+400	46+600	11.200
24+400	28+000	3.600	98+600	100+600	2.000	52+000	52+800	0.800
29+200	35+400	6.200	101+600	102+000	0.400	54+000	59+200	5.200

Pavement condition is good			Pavement condition is fair		length	Pavement condition is poor		Length
46+600	52+000	5.400				65+400	70+200	4.800
52+800	54+000	1.200				71+600	77+000	5.400
59+200	60+600	1.400				79+200	82+400	3.200
64+000	65+400	1.400				89+200	89+600	0.400
70+200	71+600	1.400				96+000	96+800	0.800
77+000	79+200	2.200				104+600	107+500	2.900
82+400	89+200	6.800						
89+600	96+000	6.400						
96+800	98+600	1.800						
100+600	101+600	1.000						
102+000	104+600	2.600						
Total	Good	58.100		Fair	7.800		Poor	36.900

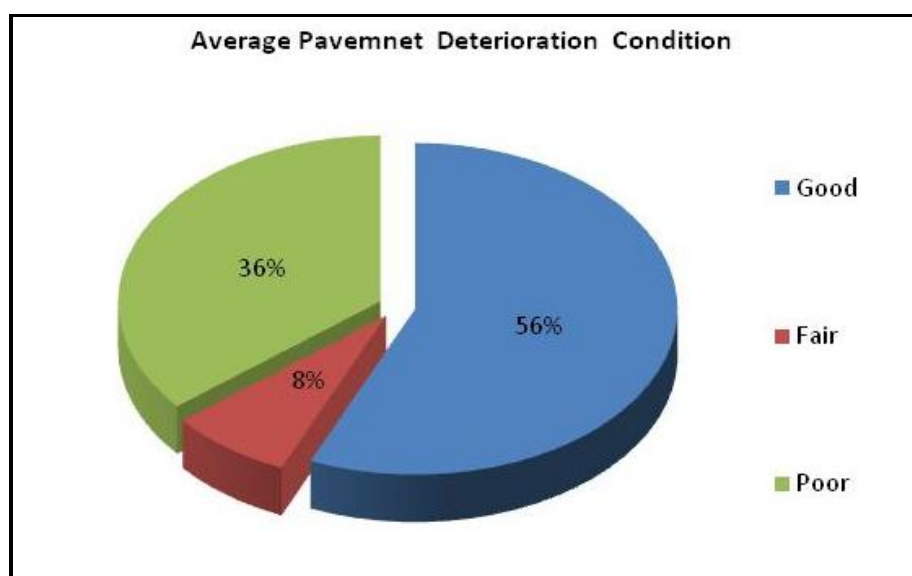


Figure 5.5: Pavement Condition Composition

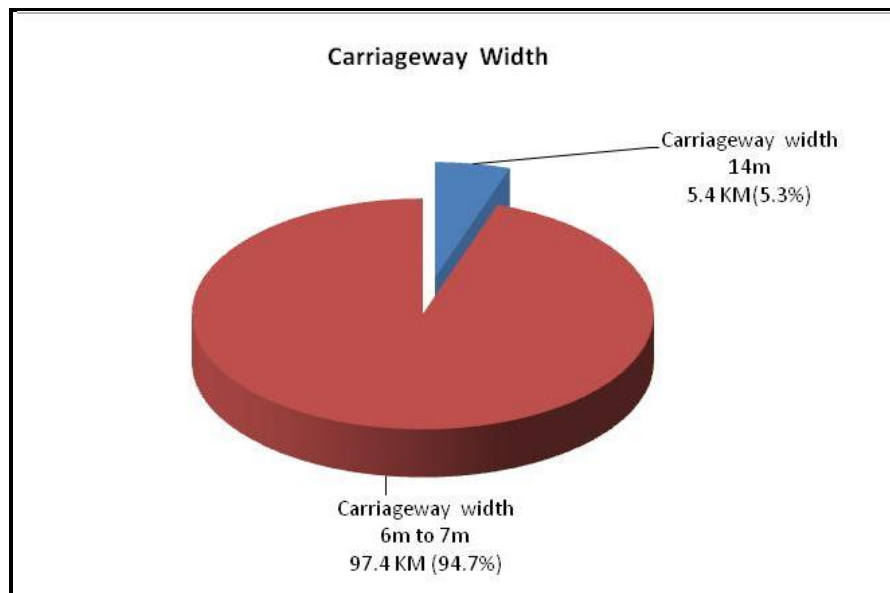


Figure 5.6: Width of the Carriageway Composition

Following specific observations were made during the survey:

- The existing pavement is flexible type having earthen shoulders. Paved shoulders are absent in the complete stretches.
- The project highway throughout in length is passes through the plain and rolling terrain, The rolling terrain lies along the project road mainly between km 4/700 to km46/400 (Jamnagar to Kalavad) and between km 72/200 and 107/500 (Jamkandorna to Dhoraji).
- Pavement condition is generally good in the stretch between Jamnagar and Kalavad whereas the pavement condition is fair to poor in the section between Kalavad and Dhoraji which is only due to inadequate maintenance.
- Land use pattern along the project corridor is mainly agricultural land and built-up. Barren land and forest area are in very few stretches along the project road.
- The existing pavement carriageway width for most of the stretch of project highway is 6.1m to 7.0m although in about 5.6 km length, where the carriageway width is 14m (4-Lane) in dense built up sections viz. Kalavad and Jamkandorna.
- The drop of shoulder edge is observed throughout the project road. The average edge drop is about 1.2 cm and maximum drop found is 2 cm.
- Material loss in the shoulder is noticed at some locations.

5.7.2 Pavement History

The existing pavement is flexible type having earthen shoulders. Paved shoulders are absent in the complete stretches. The existing pavement carriageway width for most of the stretch of project highway is 6.1m to 7.0m although in about 5.6 km length, where the carriageway width is 14m (4-Lane) in dense built up sections viz. Kalavad and Jamkandorna. Pavement condition is generally good in the stretch between Jamnagar and Kalavad where as the pavement condition is fair to poor in the section between Kalavad and Dhoraji which is only due to inadequate maintenance.

During the initial site visit following defects were generally noted:

- Cracking (alligator, transverse, longitudinal, edge)
- Patching
- Raveling
- Potholes
- Edge breaking
- Depressed shoulders

The surface is poor especially in those stretches where periodic maintenance by the way of renewal has not been done for quite some time. The pavement, in about 60km of length, is with fair to poor condition. The side drainage is generally available along the project stretch. The road surface is black topped with SDBC in some portion and with Premix carpet in rest of section. At most of the locations the last overlay was done with SDBC while in some stretches BM was laid under PMC. Last five years pavement history given below in Table:

Table 5.6: Pavement History in Last Five Years

Location	Length	Year	Treatment
Jamnagar – Kalavad Road Up to Rajkot District Limit (S.H No. 26 Km. 4/7 to 72/2)			
45+2 to 46+4	1.200	2009-10	Widening to 4 lane 300mm GSB, 250mm WBM, 75mm BUSG, 50mm BM, 25mm Thick SDBC
51+315 to 52+200 52+2 to 53+4 59+2 to 59+8 70+2 to 70+7	2.300	2009-10	37.50mm BUSG + 50mm BM + 25mm SDBC

Location	Length	Year	Treatment
53+4 to 54+50	1.500	2009-10	75mm BUSG + 50mm BM + 25mm SDBC
54+950 to 59+2 54+8 to 65+6	10.050	2010-11	78/37.5mm BUSG + 75mm BM, 25mm SDBC
4+7 to 5+350	14.050	2011-12	150mm WMM + 37.50mm2014 BUSG + 50mm BM + 25mm SDBC
7+0 to 9+840			
16+0 to 19+0			
16+850 to 70+2			
70+685 to 71+700			
65+6 to 65+825	0.250	2012-13	50mm DBM + 25mm SDBC
10+0 to 11+8 48+8 to 51+3	4.300	2013-14	50mm DBM + 25mm SDBC
19+0 to 36+0	17.000	2013-14	50mm DBM + 30mm BC
Rajkot Dist. Limit to Jamkandorna–Dhoraji (S. H. No. 26 Km 72/2 to 108/6)			
72+2 to 79+5	7.300	2007-08	50mm BM + 20mm MSS
79+5 to 83+0	3.500	2007-08	
94+50 to 103+50	9.000	2009-10	50mm BM + 25mm SDBC
103+50 to 108+0	4.500	2009-10	75mm WBM + 75mm BM + 25mm SDBC
88+8 to 93+5	4.700	2009-10	50mm BM + 25mm SDBC
93+5 to 94+50	1.000	2011-12	75mm BUSG + 50mm BM + 25mm SDBC
83+0 to 89+0 89+0 to 91+0	6.000 2.000	2014-15	37.50mm BUSG + 50mm BM + 25mm SDBC
91+0 to 93+5	2.500	2014-15	75mm BUSG + 50mm BM + 25mm SDBC

Pavement condition of the project road is shown in the photographs below:



Pavement Condition at Km 7+000



Pavement Condition at Km 13+500



Pavement Condition at Km 29+000



Pavement Condition at Km 106+000

Figure 5.7: Pavement Condition of the Project Road

5.7.3 Pavement Roughness Survey

Surface evenness affects the vehicle speed, operating cost, comfort, safety and travel time. Hence it is necessary prior to construction to evaluate the surface evenness. The roughness survey has been carried out for the whole length of the project road using Fifth Wheel Bump Integrator. **Figures below** depict the roughness survey along the project road. The calibration for Roughness measurement has been done as per the procedure given in IRC: SP: 16-2004. The survey covered two runs along the wheel paths for each lane and results have been expressed in the terms of BI (mm/km). Further, whole stretch has been delineated using Cumulative Difference Approach and based on this homogeneous sections have been identified.

The discomforts & disturbances are subjected to road surface irregularity. Hence it is necessary to evaluate the same for necessary action & correction.

A careful consideration during initial construction & subsequent maintenance is mandatory. As per IRC: SP: 16-2004, a standard speed of 32 ± 1 km/hr. has an important meaning in roughness measurements. The road roughness is affected by the vehicle speed. A bump gets magnified if the vehicle speed is not maintained. A standard pneumatic tyre wheel inflated to a tyre pressure of 2.1 kg/sqcm is mounted within the trailer chassis. The distance traveled is measured by a distance measuring unit. The test is conducted at a speed of 32 ± 1 km/hr. Unevenness/roughness Index is defined as the ratio of the cumulative vertical displacement to the distance traveled and is expressed in mm/km. For measurement of roughness, one measurement in each lane is recommended for riding comforts evaluation.

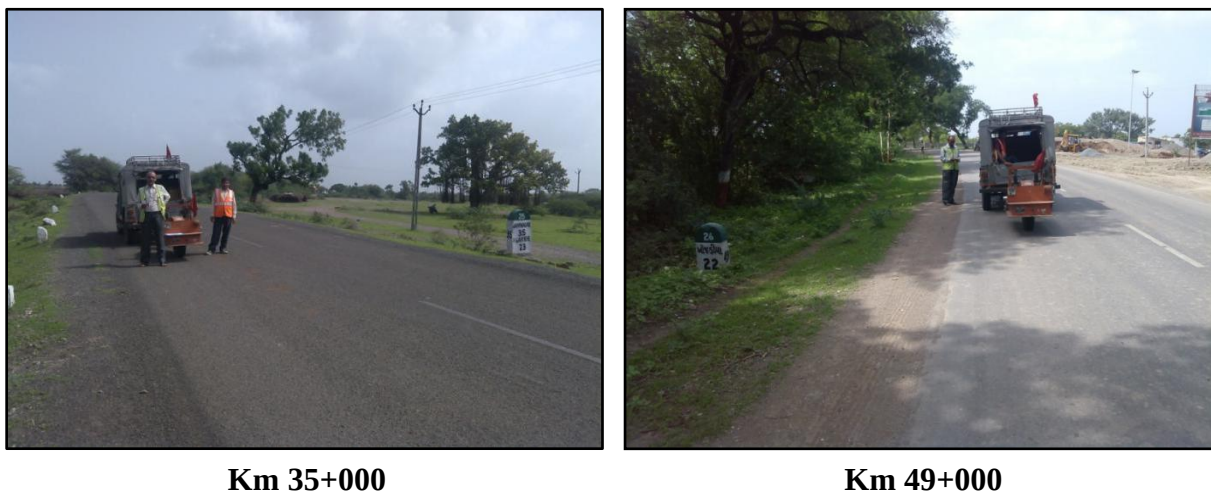


Figure 5.8: Roughness Survey

Maximum permissible values, BI in mm/km as per guidelines, are given in the **Table below**. Herein Condition of the road surface is categorized in three groups, 'Good', 'fair' & 'Poor' based on BI values.

Good category indicates newly constructed surfaces with respect to roughness values. The values under Average & Poor correspond to level of service & intervention level for maintenance. Surfaces with very low roughness values lose skid resistance & are dangerous as regards safety. Due frictional resistance should be provided at the earliest before road accidents occur unnecessarily & unavoidably.

The roughness survey was carried out using Fifth Wheel Bump Integrator. The survey was carried out along the outer wheel paths. The results of the survey were expressed in terms of BI and also in terms of IRI by using the following equation.

$$BI = 630(IRI)^{1.12}$$

Where BI = Bump Integrator Roughness in mm/km

IRI = International Roughness Index in m/km

The processed data were analyzed using the cumulative difference approach to identify road segments homogenous with respect to surface roughness. The roughness cumulative difference chart is given in **Figure** below. The surveys had covered one run along the wheel paths for each direction & the average of the two gave BI for every 100 m run. Final average of 10 readings produced BI for that particular kilometer. The Roughness Survey data details are given in **Appendix-5.3 (Volume-II, Part-II of Draft Feasibility Report)**.

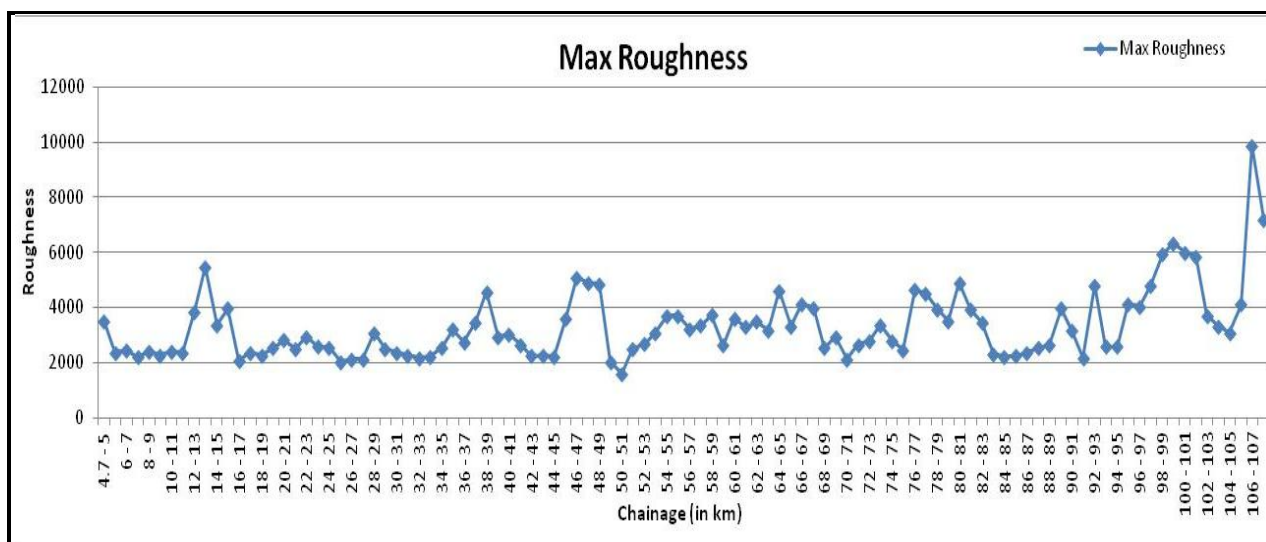


Figure 5.9: Roughness Cumulative Difference Chart

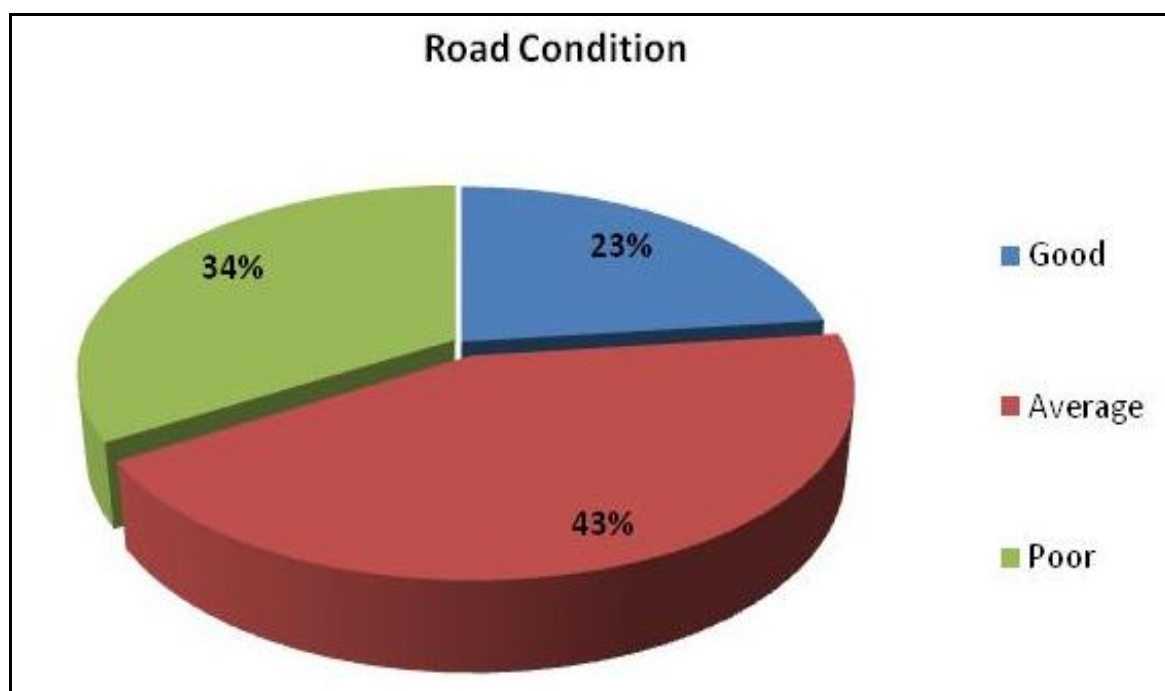


Figure 5.10: Pavement Condition Composition

Table 5.7: Pavement Condition

Condition	Total KMs
Good	24
Average	45
Poor	35

5.7.4 Existing pavement structural strength (BBD)

Structural strength surveys for existing two lane pavement using Benkelman Beam Deflection Technique were carried out in accordance with the procedure given in IRC: 81-1997 “Guidelines for Strengthening of Flexible Road Pavements using Benkelman Beam Deflection Technique”.

Calculations of Deflections

To get a single value of rebound deflection from three field values (Initial, Intermediate & Final Readings) following steps are followed:

Step 1	Double the field observations (readings): D_o , D_i & D_f are doubled values. This is done because the dial gauge is fixed such that distance between probe end and fulcrum of beam is twice the distance between fulcrum and dial gauge.
Step 2	Let Initial Reading be D_o (doubled), Intermediate Reading be D_i (doubled), & Final Reading be D_f (doubled) & X_T & Y_T is rebound deflections in mm in case 1 & 2 respectively.
Case 1	If $D_f - D_i < 0.025\text{mm}$ $X_T = \text{rebound deflection} = 2 (D_f - D_o)$ = twice the difference between final and initial readings
Case 2	If $D_f - D_i \geq 0.025\text{mm}$ $Y_T = \text{rebound deflection}$ $= 2 (D_f - D_o) + 2 \times 2.91 (D_f - D_i)$
Step 3	After this temperature & seasonal corrections were applied to get final (corrected) deflection from which, mean, standard deviation and characteristic deflection are obtained.

Characteristic Deflection

The statistical analysis of all the measurements done in the field and corrections applied as required was done as under:

$$\text{Mean deflection} = \bar{X} = \frac{\sum X}{N}$$

$$\text{Standard deviation} = \sigma = \sqrt{\frac{\sum (X - \bar{X})^2}{n-1}}$$

The characteristic deflection for design purposes has been taken as

Characteristic deflection D_c in mm = $\bar{X} + 2\sigma$ for major arterial roads (like NH & SH)

$D_c = \bar{X} + \sigma$ could be considered for all other roads but for this project it is not applicable.

Here, X = Individual deflection in mm

$\bar{X}$ = Mean deflection in mm

n = Number of deflection measurements

In the formula for standard deviation, division by $n-1$ and not n follows the established statistical theorems.

In the same km on road, readings were staggered at an interval of 50m on either side, Left Hand (LHS) and Right Hand (RHS). The observations of LHS were taken while traveling from Dhoraji to Jamnagar and RHS while traveling from Jamnagar to Dhoraji, involving a difference of several days. Hence, calculated characteristic deflection for LHS is bound to be different for RHS in the same km. The representative characteristic deflection for the same km is the maximum of the two and not the average for the obvious reasons. The detailed BBD data and its analysis for the project road stretch under report are given in **Appendix-5.4 (Volume-II, Part-II of Draft Feasibility Report)**. Figure below shows the BBD testing at km 69 & 104.



Km 69+000



Km 104+000

Figure 5.11: BBD Testing

The deflection data of the given stretch of the road is as follows:

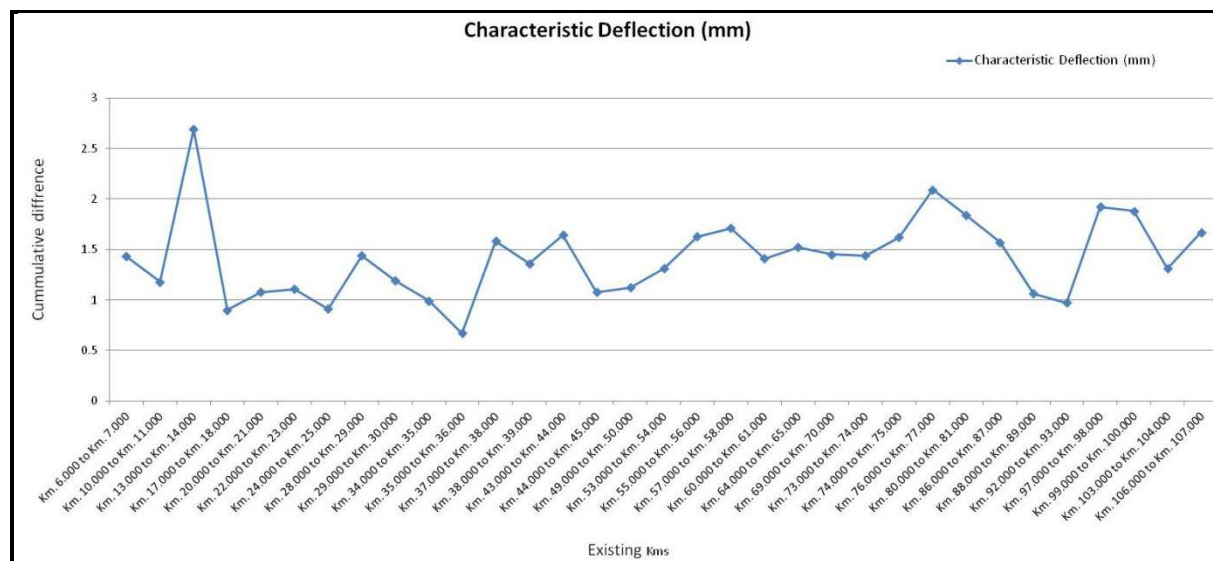


Figure 5.12: Characteristics Deflection Graph

Table 5.8: Characteristics Deflections for Road Stretch

Section (Km.)	Characteristic Deflection (mm)
Km. 6+000 to Km. 7+000	1.43
Km. 10+000 to Km. 11+000	1.18
Km. 13+000 to Km. 14+000	2.69
Km. 17+000 to Km. 18+000	0.9
Km. 20+000 to Km. 21+000	1.08
Km. 22+000 to Km. 23+000	1.11
Km. 24+000 to Km. 25+000	0.91
Km. 28+000 to Km. 29+000	1.44
Km. 29+000 to Km. 30+000	1.19
Km. 34+000 to Km. 35+000	0.99
Km. 35+000 to Km. 36+000	0.67
Km. 37+000 to Km. 38+000	1.58
Km. 38+000 to Km. 39+000	1.36
Km. 43+000 to Km. 44+000	1.64
Km. 44+000 to Km. 45+000	1.08
Km. 49+000 to Km. 50+000	1.12

Section (Km.)	Characteristic Deflection (mm)
Km. 53+000 to Km. 54+000	1.31
Km. 55+000 to Km. 56+000	1.63
Km. 57+000 to Km. 58+000	1.71
Km. 60+000 to Km. 61+000	1.41
Km. 64+000 to Km. 65+000	1.52
Km. 69+000 to Km. 70+000	1.45
Km. 73+000 to Km. 74+000	1.44
Km. 74+000 to Km. 75+000	1.62
Km. 76+000 to Km. 77+000	2.09
Km. 80+000 to Km. 81+000	1.84
Km. 86+000 to Km. 87+000	1.57
Km. 88+000 to Km. 89+000	1.06
Km. 92+000 to Km. 93+000	0.97
Km. 97+000 to Km. 98+000	1.92
Km. 99+000 to Km. 100+000	1.88
Km. 103+000 to Km. 104+000	1.31
Km. 106+000 to Km. 107+000	1.67

5.8 MATERIAL INVESTIGATIONS

5.8.1 Introduction

This project consists of road section of Jamnagar to Dhoraji on NH-927D from Km. 4.700 to Km. 107.500 in the State of Gujarat. To identify potential sources of materials for construction, the survey of following materials have been carried out to find their likely sources, availability and suitability for the purpose. This report includes detailed investigation of materials and their potential sources with the relevant laboratory tests conducted on representative samples.

5.8.2 Objectives of the investigation

In order to widen and strengthen the road and bridges, various kinds of materials such as subgrade soil, borrow area soil and granular sub-base material, fine and coarse aggregates are required. The objective of this investigation is to identify the potential sources of these materials and to assess their availability and suitability for construction work.

5.8.3 Scope of Work

Scope of work includes:

- Study of available information
- Demarcation of the possible borrow areas
- Site inspection and assessment of sources and quantity of potential materials
- Sampling of representative materials and preparation of Mass Haul Diagram/Lead chart with the name and location of borrow area /Quarry.
- Determination of the quantity and engineering properties of soil for design of embankment and sub grade and of aggregates to assess their suitability in pavement and structures.

5.8.4 Survey Methodology

Field investigation was carried out to find potential sources of material and to collect representative samples for further testing. The investigations of the materials were initially restricted along the respective road alignments and nearby sources adjoining to road section. When suitable information was not available, the reconnaissance extended towards further more kilometers where potential sources were found and where access was not a major constraint. Sub surface drilling or trenching was not carried out, however at most of sites there were sufficient existing quarries and /or exposed faces to enable a reasonable and conservative estimation of quality and quantity.

The collected representative samples were undergone for the laboratory investigations, details of which are given in the section 1.6. The results of the laboratory investigations are summarized in tabular form in the following concerned chapters. The results are discussed in details and their suitability is assessed in accordance to MORT&H provisions.

5.8.5 Mass Haul Diagram

The Mass Haul Diagram/ Lead chart is presented in **Appendix-5.5 (Volume-II, Part-II of Draft Feasibility Report)**. It shows the major locations of quarries and the average lead of materials like soil, fine and coarse aggregates. The material volume estimation is largely based upon geological judgment such as appropriate covered area, average depth of materials, nature of underlying materials, weathering characteristics and consequent effects on material properties etc.

5.8.6 Laboratory Investigations

Laboratory investigations were conducted on the collected representative samples according to the provisions mentioned in various IS codes (see below) to establish the engineering characteristics of various materials. Brief of the tests conducted and the results obtained are presented herein.

Subgrade Soil

- Gradation (IS:2720(Part-IV)-1985)
- Atterberg's Limits (IS:2720(Part-V)-1985)
- Modified Proctor Test (IS:2720(Part-VIII)-1983)
- California Bearing Ratio (CBR) (IS:2720(Part- XVI)-1987)
- Free Swell Index ((IS: 2720, Pt - XL)

GSB Soil

- Gradation (IS:2720(Part-IV)-1985)
- Atterberg's Limits (IS:2720(Part-V)-1985)
- Modified Proctor Test (IS:2720(Part-VIII)-1983)
- California Bearing Ratio (CBR) (IS:2720(Part- XVI)-1987)
- Free Swell Index (IS: 2720, Pt - XL)

Borrow Area Soil

- Gradation (IS:2720(Part-IV)-1985)
- Atterberg's Limits (IS:2720(Part-V)-1985)
- Modified Proctor Test (IS:2720(Part-VIII)-1983)
- California Bearing Ratio (CBR) (IS:2720(Part- XVI)-1987)
- Free Swell Index (IS: 2720, Pt - XL)

Fine Aggregate /Sand

- Gradation (IS:383 -1970)
- Silt content and Fineness Modulus (IS:383 -1970)
- Specific Gravity (IS:2386(Part-III)-1963)

Coarse Aggregate

- Impact Value (IS:2386(Part-IV)-1963)
- Abrasion Value (IS:2386(Part-IV)-1963)
- Specific Gravity (IS:2386(Part-III)-1963)
- Water Absorption(IS:2386(Part-III)-1963)

- Flakiness & Elongation Index (IS:2386(Part-I)-1963)
- Stripping Value (IS:6241-1971)

5.8.7 Laboratory Test Result

Subgrade Soil

The laboratory tests carried out for the soil samples collected from 1000 mm × 1000 mm pits revealed that soil along the alignment is predominantly Silty Sand in nature with fractions of medium plastic clay and gravels. OMC value varies from 9.00% to 18.00% and those of MDD vary from 1.75 gm/cc to 2.18 gm/cc.

Further soaked CBR values vary from 1.6% to 14% at field density and vary from 3.6% to 39.6% at 97% of MDD.

The laboratory test results are given in tabular form in **Appendix-5.6 (Volume-II, Part-II of Draft Feasibility Report)**.

GSB Soil

The test results of GSB soil are generally Sandy Gravels. OMC value varies from 5.5 to 12.0 % and that of MDD is from 2.00 to 2.36 gm/cc. CBR value varies from 28 to 38 %. Test results of GSB soil are presented in **Appendix-5.7 (Volume-II, Part-II of Draft Feasibility Report)**.

Borrow Area Soil

Test results of Soil in borrow areas are generally Gravelly Sand with fractions of Silt and also a little clay at the locations 29+200, 80+200 and 102+000. Generally the strata are Non-Plastic. OMC values vary from 8.00 % to 18.00 % and those of MDD vary from 1.78 gm/cc to 2.22 gm/cc. The CBR value at 97% MDD generally ranges from 9 % to 31 %.

Before the approvals of any borrow area all the relevant laboratory tests shall be conducted to assess the quality of the soil material. Economic aspect shall be duly considered in selecting borrow area.

The Borrow Area test results are given in tabular form in **Appendix-5.8 (Volume-II, Part-II of Draft Feasibility Report)**.

Fine Aggregates (Sand/Stone Dust)

Sand Quarries in this area and its corresponding lead from project corridor as follows:

- Stone Dust, Lead 1.0 km from CH: 4+800 (RHS), Theba Village
- Stone Dust, Lead 1.0 km from CH: 8+700 (RHS), Motu Thawariya Quarry
- Stone Dust, Lead 1.0 km from CH: 12+100 (LHS), Vijrakhi Quarry

- Stone Dust, Lead on road on CH: 55+000 (LHS), Makrani Sarosana
- Sand Quarry, Lead 3.0 km from CH: 90+500 (LHS), Phophal River, Boriya
- Stone Dust, Lead 2.0 km from CH: 98+100 (LHS), Jam Kandora Quarry, Rajkot
- Sand Quarry, Lead 2.0 km from CH: 102+000 (LHS), Bhadar River, Vegadi Village.

The test results of sand and stone dust samples are shown in **Appendix-5.9 (Volume-II, Part-II of Draft Feasibility Report)**. The fine aggregate samples collected as per IS 383 lies in zone I for all the locations.

The fineness modulus of fine aggregate lies in the range 3.61 to 3.94 implies that sand from all the locations falls outside the specifications of MORTH (Between 2.0 and 3.5). Specific gravity of these fine aggregate samples lies between 2.66 to 2.89.

Coarse Aggregate

Detailed survey on the project was done and it was revealed that the stone quarries in this area and its corresponding leads are as follows:

- Kudarat Stone Crusher, Lead 1.0 km from CH: 4+800 (RHS), Theba Village
- Rudra Stone Crusher, Lead 1.0 km from CH: 8+700 (RHS), Motu Thawariya Quarry
- Bhagwat Material Industries, Lead 1.0 km from CH: 12+100 (LHS), Vijrakhi Quarry
- Vaibhav Stone Crusher, Lead on road on CH: 55+000 (LHS), Makrani Sarosana
- Vaibhav Stone Crusher, Lead 2.0 km from CH: 98+100 (LHS), Jam Kandora Quarry, Rajkot.

Test result of coarse aggregates satisfies the requirements of Los-Angeles abrasion value, impact value, stripping value and Specific gravity and water absorption values as per MORTH requirements. But these Quarries do not satisfy the requirement of flakiness and elongation values as given in **Appendix-5.10 (Volume-II, Part-II of Draft Feasibility Report)**.



CHAPTER - 6

INDICATIVE DESIGN STANDARDS

CHAPTER - 6

INDICATIVE DESIGN STANDARDS

6.1 DESIGN STANDARDS FOR ROAD

- (i) The project highway shall be developed to 4- lane with paved shoulder configuration in general. As the project stretch is passing plain and rolling terrain, paved shoulders shall be provided 2.0 m wide in built up area and 1.5 m wide in open country.
- (ii) The geometric design of the Project Road shall conform to the standards set out hereinafter as a minimum.
- (iii) As far as possible uniformity of design standard shall be maintained taking into consideration the type of terrain, the road passing through. In case of any change, it shall be affected in a gradual manner.
- (iv) Where widening of project road and its improvement to the prescribed standard requires acquisition of additional land, the design and improvement will be planned in such a way that minimum land need to be acquired.
- (v) Existing horizontal curves, which are found deficient in radius, layout, transition lengths or super elevation, shall be corrected to the specified standards.
- (vi) Any deficiencies in the vertical profile in respect of grades, layout of vertical curves, sight distance, shall be corrected to meet the minimum specified requirements.

6.1.1 Design Speed

- (i) The design speeds given in **Table 6.1** shall be adopted for various terrain classifications (Terrain is classified by the general slope of the ground across the highway alignment).

Table 6.1: Design Speed

Name of Terrain	Cross Slope of the Ground	Design speed km/hr	
		Ruling	Minimum
Plain and Rolling	Up to 25 percent	100	80

- (ii) In general, the ruling design speed shall be adopted for the various geometric design features of the road. Minimum design speed shall be adopted where site conditions are restrictive and adequate land width is not available.

6.1.2 Right of Way (ROW)

Four laning shall be accommodated within total 45-50m including 24m available. However, additional land, if required for accommodating for improvement of geometrics, realignment, junctions, bypasses etc., shall be acquired. For bypasses, Right of Way shall be 60m.

6.1.3 Lane Width of Carriageway

The standard lane width of the Project Road shall be 3.5 m.

6.1.4 Shoulders

The shoulder width shall be provided as per given in **Table 6.2** below.

Table 6.2: Width of Shoulder in Plain and Rolling Terrain

Type of Section	Width of Shoulder (m)		
	Paved	Earthen	Total
Open country with isolated built-up area	1.50	1.00	2.50
Built up Area (4-lane section)	2.5	-	2.5
Approaches to Grade Separated Structure	-	-	-
Approaches to Bridges	1.50	1.00	3.50

The type of shoulder shall be as follows:

- (i) In the built-up section, the shoulder shall be fully paved of 2.50m width and no earthen shoulder shall be provided.
- (ii) Width of paved shoulders in approaches to grade separated structures as indicated in Table above shall extend on either side of the structure in the entire length of retaining/RE wall. The retaining/RE wall on either side shall be abutting the paved shoulders and shall have crash barriers on top.

6.1.5 Roadway Width

The width of roadway including shoulders, unless specified otherwise, shall be as follows:

For Plain and Rolling Terrain

- Open Country (4-lane configuration) - 24.0 m (7m Carriageway, 1.50m paved shoulder & 1.0m earthen shoulder on either side + 5.0m median including 0.50m shy on either side of median).
- Built-up Area (4-lane Configuration) - 47.0m (2.50m median including 0.50m shy on

either side of median + 7m Carriageway, 2.5m paved shoulder, 1.75m for footpath including 0.50m space for railing, 7.50m wide service road, 1.50m footpath cum drain & 2.0m wide space for services on either side).

- Bypasses (4-lane Configuration) - 24.0 m (7m Carriageway, 1.50m paved shoulder & 1.0m earthen shoulder on either side + 5.0m median including 0.50m shy on either side of median).

6.1.6 Extra Widening

On horizontal curves with radius up to 300m, width of pavement and roadway shall be increased as per **Table 6.3**.

Table 6.3: Extra Width of Pavement and Roadway in Each Carriageway

S. No.	Radius of Curve	Extra Width
1	75-100 m	0.9 m
2	101-300 m	0.6 m

6.1.7 Cross fall or Camber

- (i) The camber or cross fall on straight sections of road carriageway and shoulders shall be as per **Table 6.4**.

Table 6.4: Camber/Cross fall in percentage for different Surface Types

S. No.	Category of Surface	Camber
1	Bituminous	2.5%
2	Cement Concrete	2.0%

- (ii) The camber for earthen shoulders on straight portion shall be at least 0.5 per cent steeper than the slope of the pavement and paved shoulder subject to a minimum of 3.0 per cent. On super elevated sections, the earthen portion of the shoulder on the outer side of the curve shall be provided with reverse cross fall of 0.5 percent so that the earth does not drain on the carriageway.

6.1.8 Sight Distance

- (i) The Project Road shall normally be designed for desirable minimum sight distance. In stretches where desirable minimum sight distance is not available, the safe stopping sight distance shall be provided. In case of Four lane configuration, a minimum of safe stopping sight distance shall be available throughout, and in case of 2 lane configuration of roads, normally intermediate sight distance should be available throughout.
- (ii) The safe stopping sight distance shall be measured taking height of driver's eye as 1.2 m and of object as 0.15 m but for intermediate (desirable) sight distance the height of object shall be taken as 1.2 m.
- (iii) The recommended sight distance for various speeds is given in **Table 6.5**.

Table 6.5: Sight Distances for Various Speeds

Speed km/h	Safe Stopping Sight Distance (m)	Desirable Minimum Sight Distance (m)
100	180	360
80	130	260
60	90	180
40	45	90

6.1.9 Horizontal Alignment

- (i) All horizontal curves shall consist of circular portion flanked by spiral transitions at both ends except where the gap between reverse curves is insufficient. Minimum radius of curve shall be adopted only when it is absolutely necessary.
- (ii) The desirable minimum and absolute minimum radii of horizontal curves for plain and rolling of terrain are given in **Table 6.6**.

Table 6.6: Minimum Radii of Horizontal Curves

Nature of Terrain	Desirable Minimum	Absolute Minimum
Plain and Rolling	400m	250m

6.1.10 Super-elevation

- (i) Super elevation shall be provided on curves as per details given in IRC: SP:84-2019 corresponding to the design speed adopted.

- (ii) Super elevation shall be limited to 7% if the radius of the curve is less than the desirable minimum and it shall be limited 5% if the radius of the curve is more than the desirable minimum.

6.1.11 Vertical Alignment

- (i) The ruling and limiting gradients are given in **Table 6.7**.

Table 6.7: Recommended Gradients

Nature of Terrain	Ruling Gradient	Limiting Gradient
Plain and Rolling	2.50%	3.30%

- (ii) Gradients up to the value corresponding to ruling gradient shall be adopted, as far as possible. Limiting gradients shall be adopted only in very short lengths; where the topography compels to use.
- (iii) Long sweeping vertical curves shall be provided at all grade changes. These shall be designed as square parabolas.
- (iv) The minimum length of vertical curve shall be provided as per requirement sight distances. However, the minimum length of vertical curve corresponding to design speed adopted shall be as given in **Table 6.8**.

Table 6.8: Minimum Length of Vertical Curve

Design Speed	Grade change not requiring a vertical curve	Minimum length of vertical curve
Up to 35	1.5	15
40	1.2	20
50	1.0	20
65	0.8	40
80	0.6	50
100	0.5	60

6.1.12 Widening Policy for the Project Road

The total length of the Project Road (package-2) is about 47.572 km. The existing project road is generally having intermediate lane or two lane width. The proposed widening to 4-lane with paved shoulders would be done as far as possible within the proposed right of way width by resorting to concentric/eccentric widening.

6.1.13 Typical Cross Section

The indicative TCS drawing are given as below:

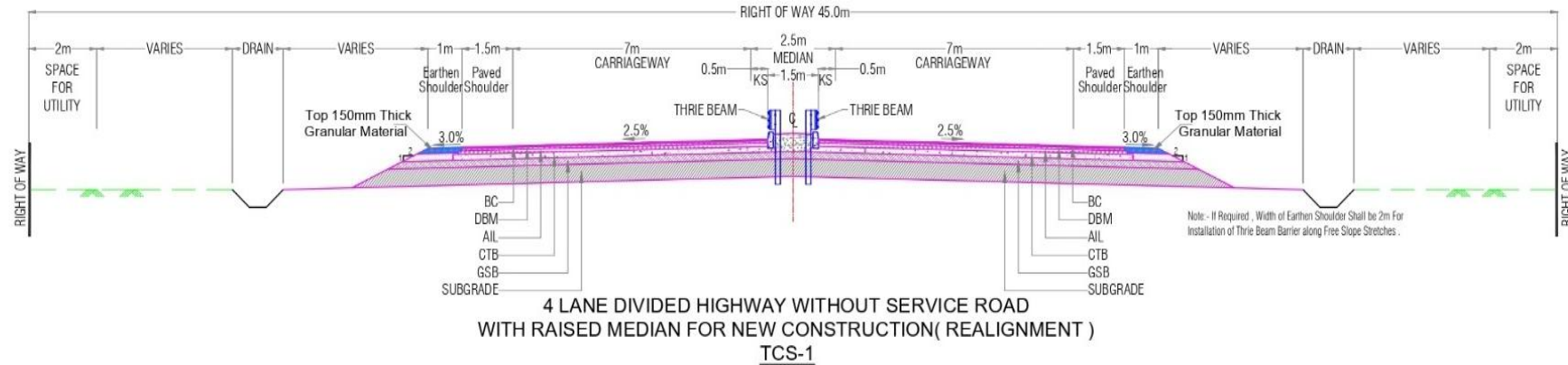


Figure 6.1: TCS-1 for 4 Lane Divided Highway without Service Road with Raised Median for New Construction (Realignment)

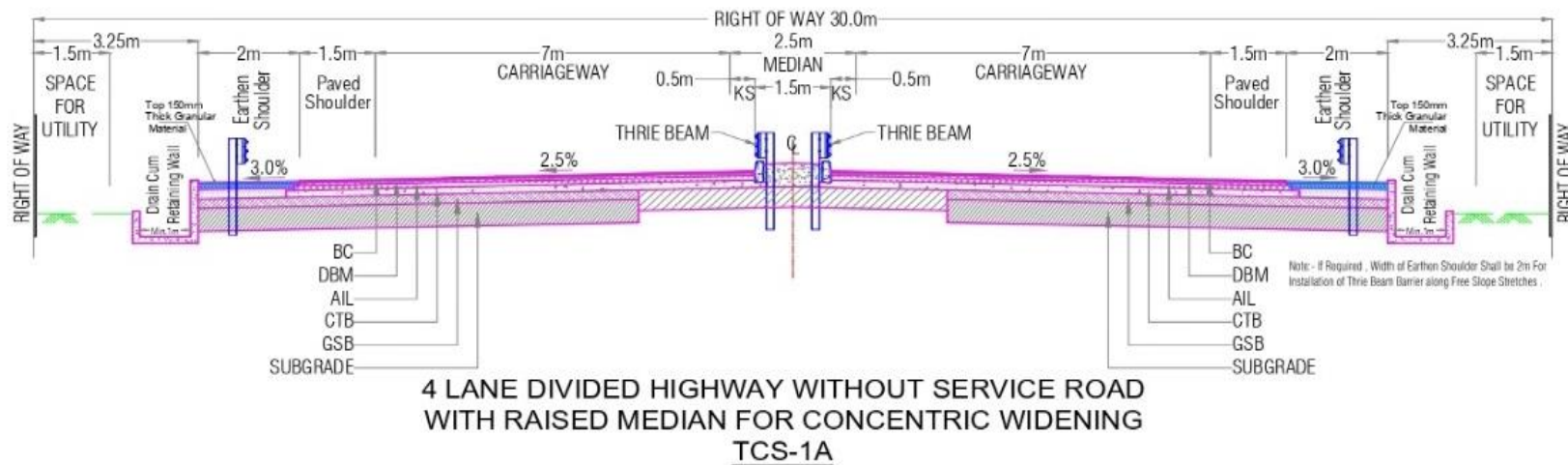


Figure 6.2: TCS-1A for 4 Lane Divided Highway without Service Road with Raised Median for Concentric Widening

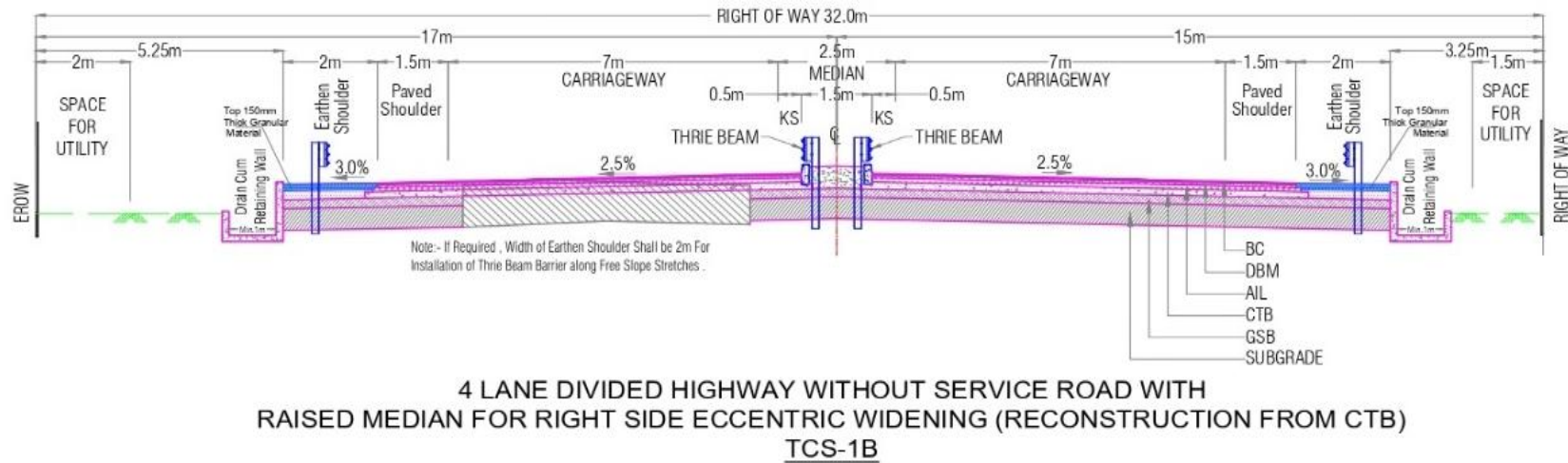


Figure 6.3: TCS-1B for 4 Lane Divided Highway without Service Road with Raised Median for Right side Eccentric Widening (Reconstruction from CTB)

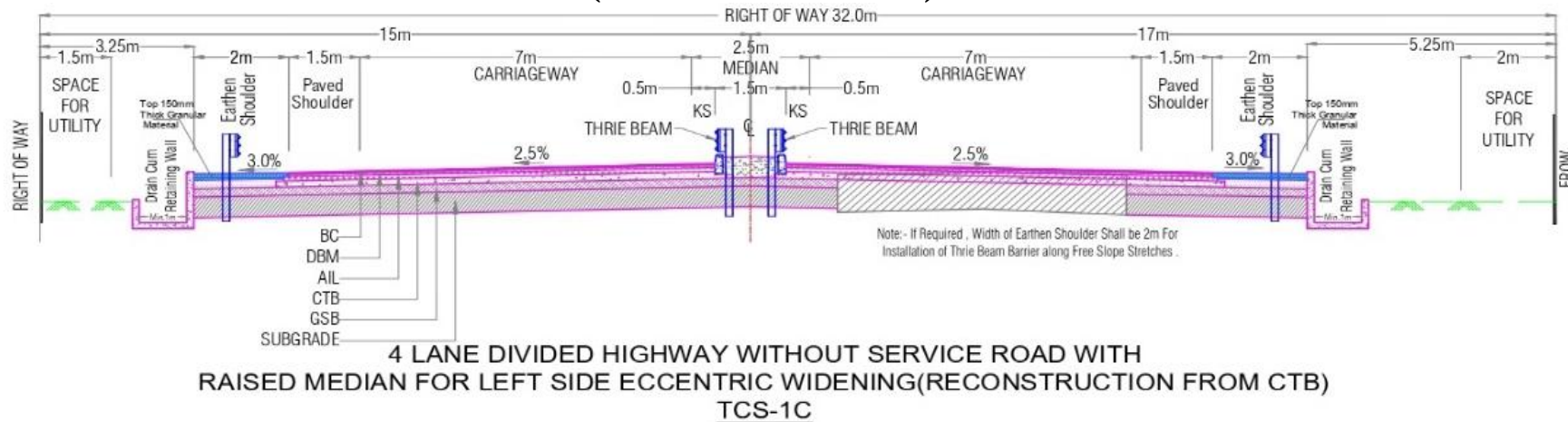


Figure 6.4: TCS-1C for 4 Lane Divided Highway without Service Road with Raised Median for Left side Eccentric Widening (Reconstruction from CTB)



Diagram illustrating the cross-section of a 4-lane divided highway reconstruction with a raised median for right side widening. The total width of the Right of Way (ROW) is 32m.

The cross-section details include:

- Left Side (from EROW to Median):**
 - SPACE FOR UTILITY: 2m
 - Top 150mm Thick Granular Material: 5.25m
 - Drain Cum Retaining Wall: Min 1m
 - Earthen Shoulder: 2m
 - Paved Shoulder: 1.5m
 - CARRIAGEWAY: 7m
 - Median: 2.5m
- Right Side (from Median to ROW):**
 - CARRIAGEWAY: 7m
 - Paved Shoulder: 1.5m
 - Earthen Shoulder: 2m
 - Top 150mm Thick Granular Material: 3.25m
 - SPACE FOR UTILITY: 1.5m

The diagram also shows the existing carriageway, drainage cum retaining walls, and various layers like BC, DBM, AIL, CTB, GSB, and Subgrade. A note specifies that the width of the earthen shoulder shall be 2m for the installation of a Thrie Beam Barrier along free slope stretches.

RECONSTRUCTION//RAISING SECTION FOR 4 LANE DIVIDED HIGHWAY WITHOUT SERVICE ROAD WITH RAISED MEDIAN FOR RIGHT SIDE WIDENING

TCS-1E

6-8

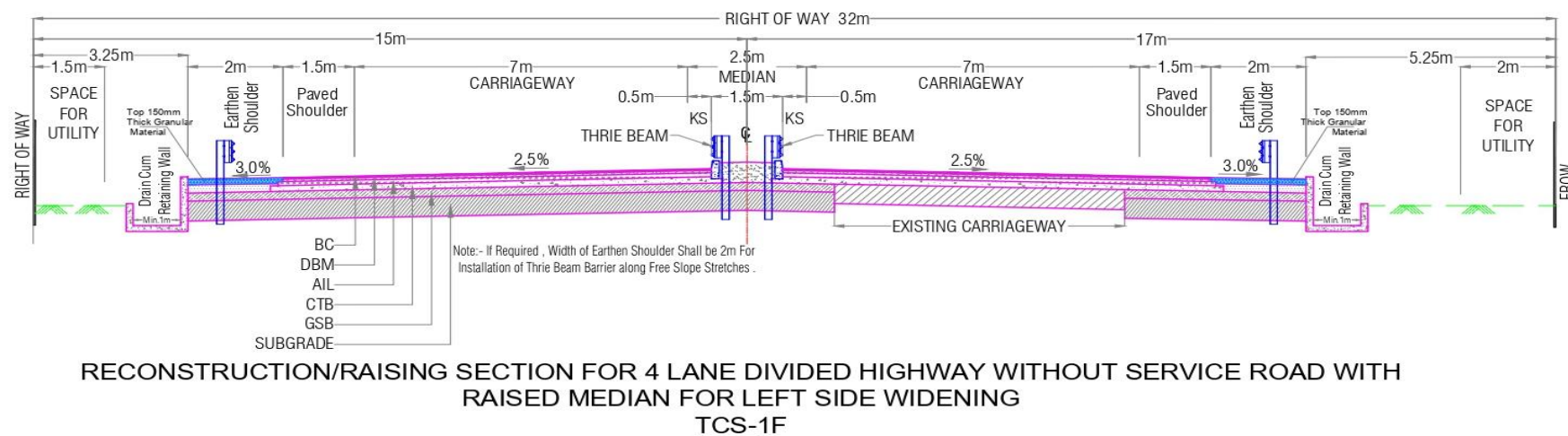


Figure 6.7: TCS-1F for Reconstruction/Raising Section for 4 Lane Divided Highway without Service Road with Raised Median for Left side Widening

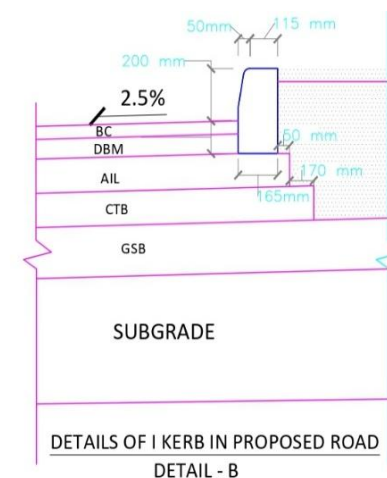
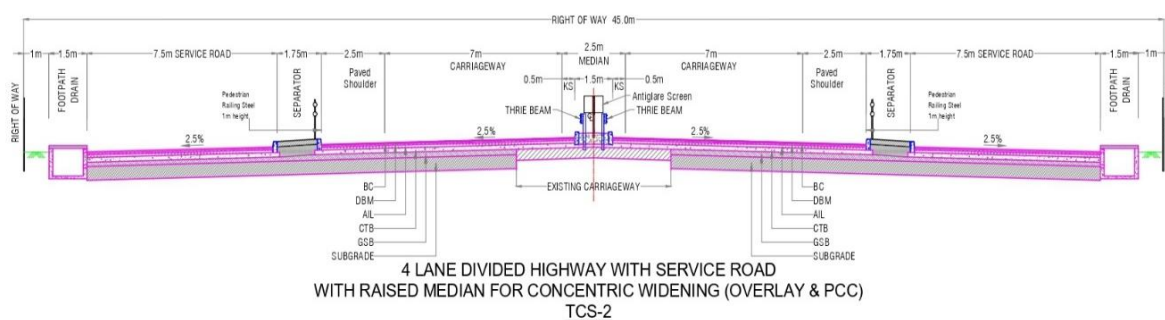


Figure 6.8: TCS-2 for 4 Lane Divided Highway with Service Road with Raised Median for Concentric Widening (Overlay & PCC)

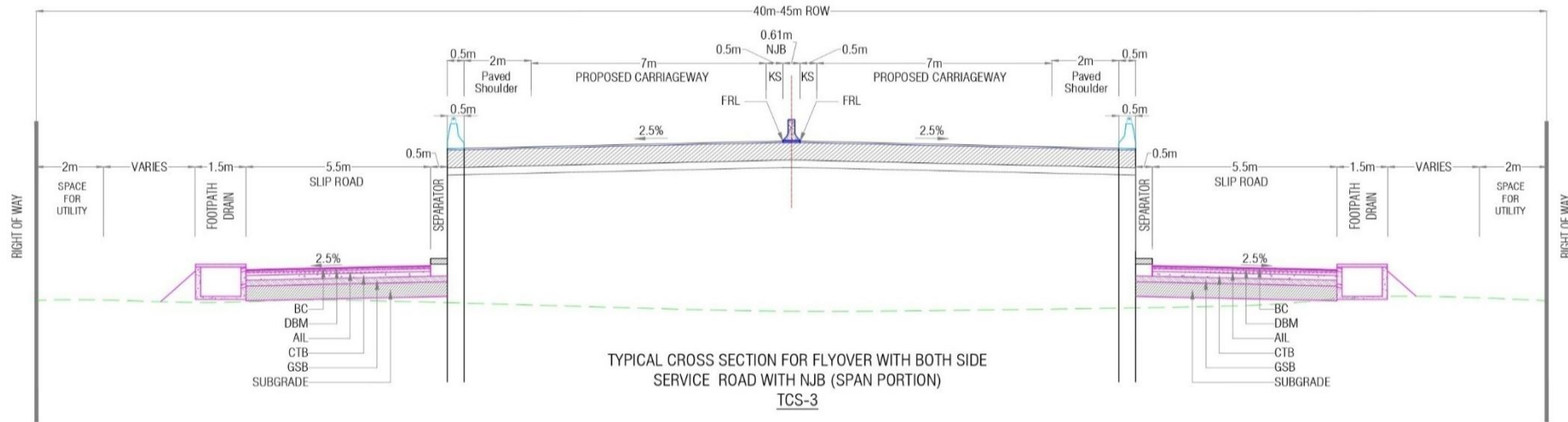


Figure 6.9: TCS-3 Typical Cross Section for Flyover with Both Side Service Road with NJB (Span Portion)

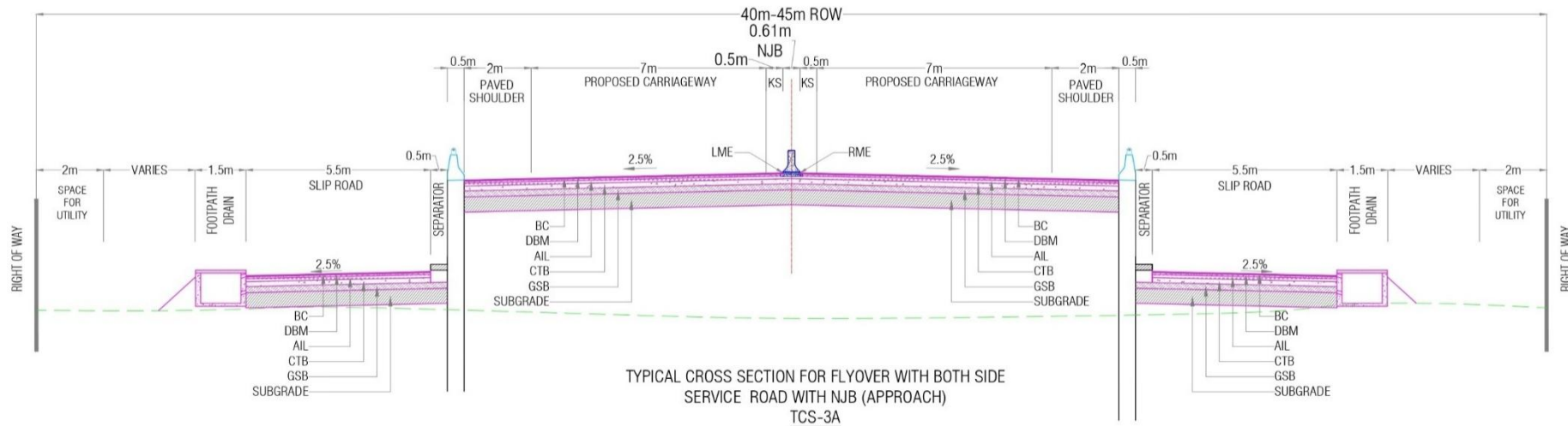


Figure 6.10: TCS-3A Typical Cross Section for Flyover with Both Side Service Road with NJB (Approach)

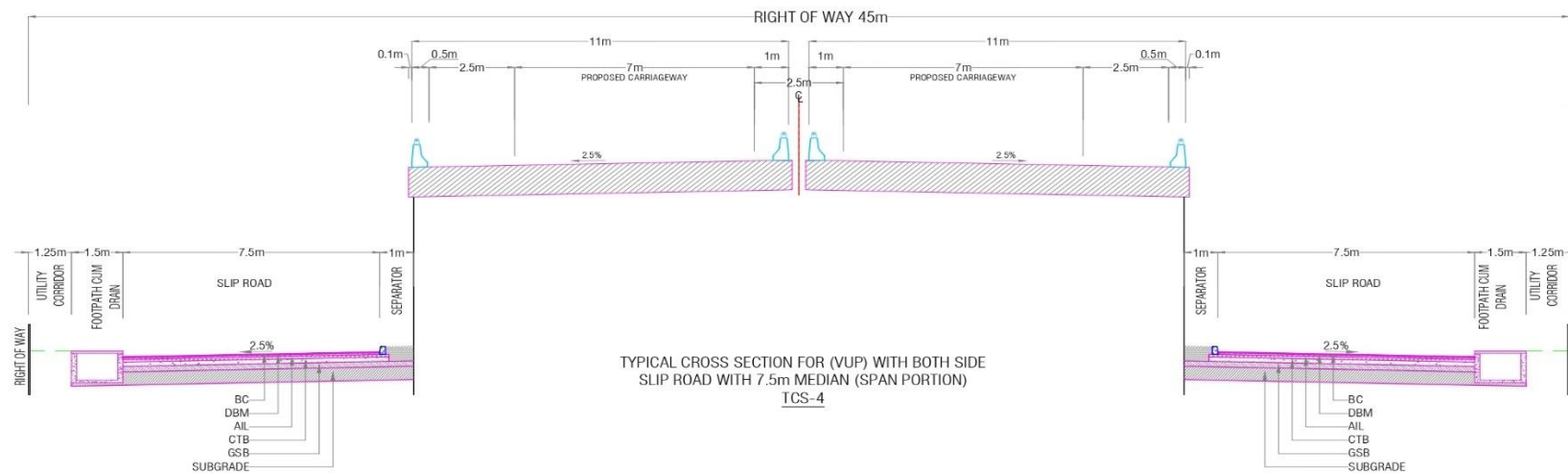


Figure 6.11: TCS-4 Typical Cross Section for VUP with Both Side Slip Road with 7.5m Median (Span Portion)

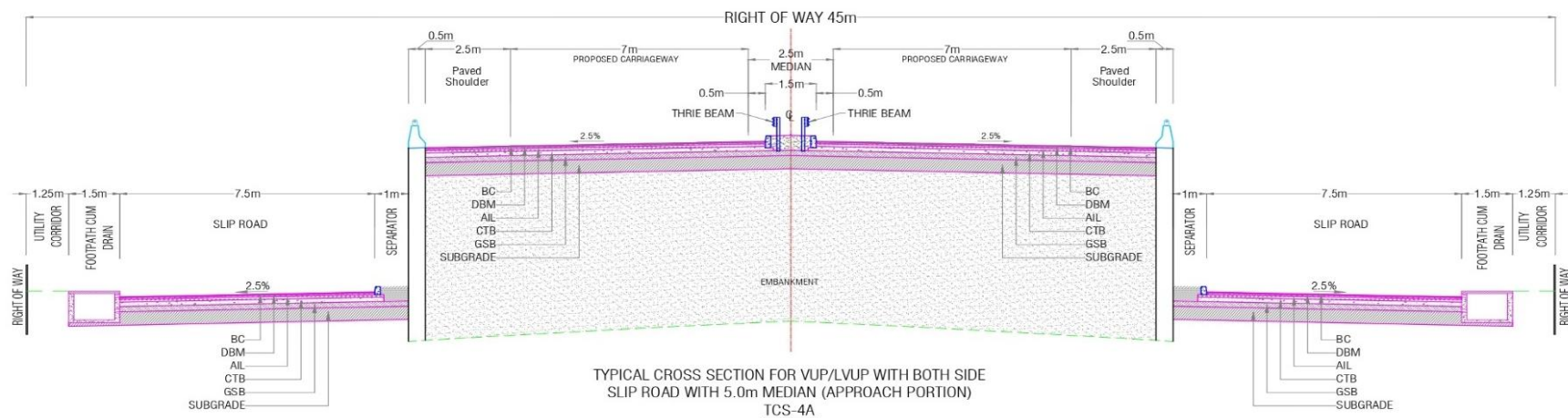


Figure 6.12: TCS-4A Typical Cross Section for VUP/LVUP with Both Side Slip Road with 5.0m Median (Approach Portion)

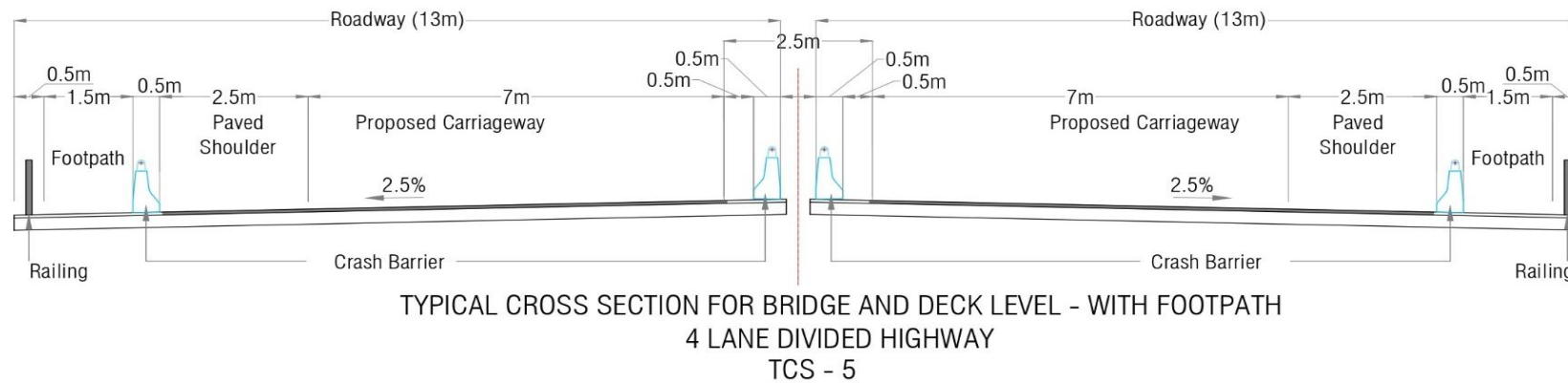


Figure 6.13: TCS-5 Typical Cross Section for Bridge and Deck Level- With Footpath 4 Lane Divided Highway

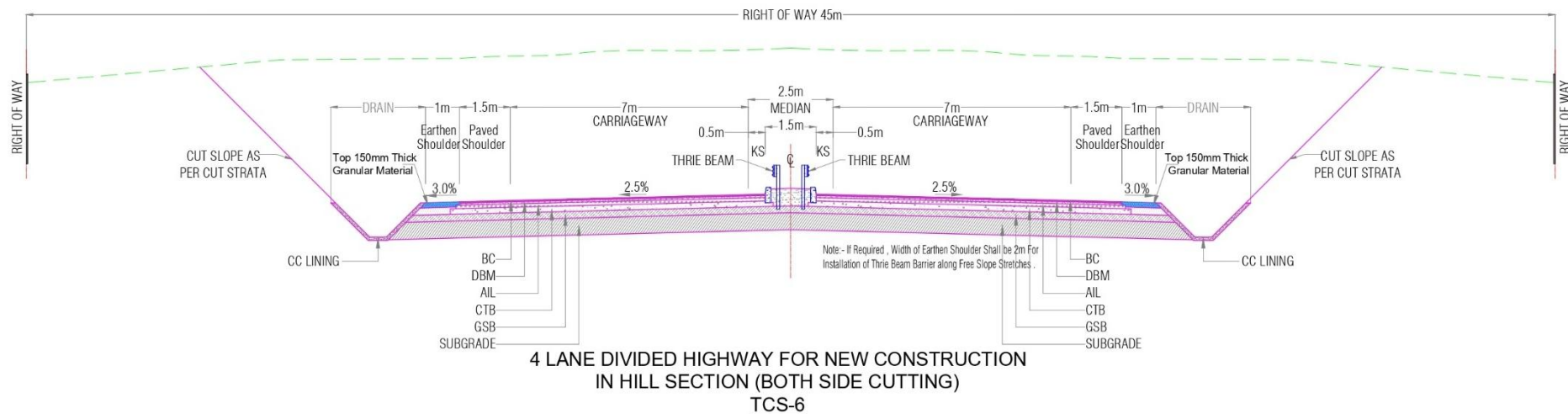


Figure 6.14: TCS-6 4 Lane Divided Highway for New Construction in Hilly Section (Both Side Cutting)

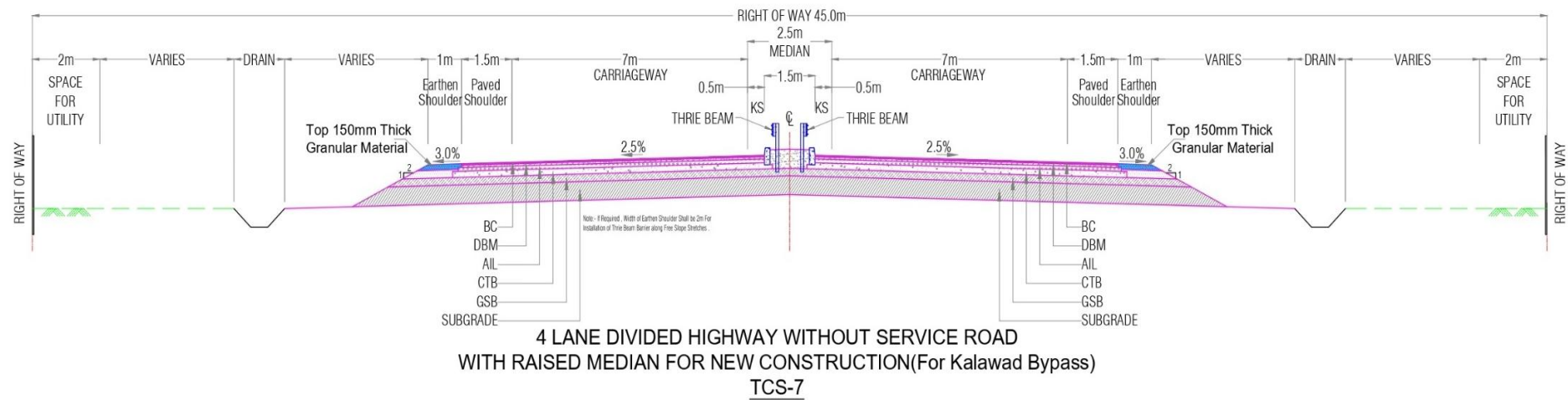


Figure 6.15: TCS-7 for 4 Lane Divided Highway without Service Road with raised Median for New Construction (for Kalavad Bypass)

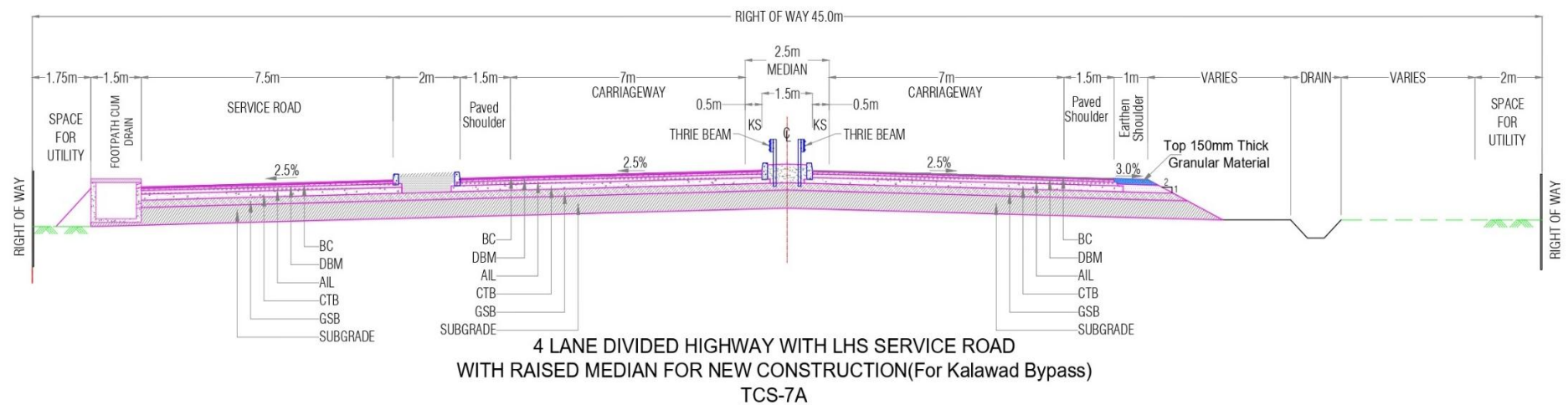


Figure 6.16: TCS-7A for 4 Lane Divided Highway with LHS Service Road with raised Median for New Construction (for Kalavad Bypass)

6.1.14 Toll Plaza

The Toll Plazas shall be provided as per NHA circular No. 17.5.82 dated 24/5/2021. Toll Plaza Shall be provided confirming to Clause 10.2 IRC: SP:84-2019.

Layout and design of toll plaza as per IRC: SP:84-2019.

S. No.	Elements	Specification
1.	Width of Toll lane	- Width of each toll lane shall be 3.2 m. - For over dimensioned vehicles 4.5 m.
2.	Traffic Island at the Toll plaza	- The island shall be of minimum 30 m length and 1.9 m width for Oversize toll lane of the toll plaza only. - For toll lane to be installed with weigh in motion system, the minimum length of island shall be 30 m where 22.5 m on approach side.
3.	Toll booth	Height of toll window shall be 0.9 m from ground level and shall have adequate space for seating of toll collector, computer, printer, cash box etc.
4.	Transition	1 in 10.
5.	Equipment for Toll Lanes	- On each lane Vehicle Counting –cum-Classifier Unit. - Semi-automatic toll collection system. - Electronically operated boom barrier along with synchronized for traffic light.
6.	Electronic Toll Collection	All lanes in each direction of travel shall be provided with ETC.
7.	Prevention of Overload	- Weigh in motion system at approaches to each toll lane are to be installed. - Separate space for static weigh bridge and area after the toll barriers for each direction of travel shall be provided.
8.	Capacity	1. Service time not more than 10 sec. 2. Electronic Toll Collection (ETC lanes). (Toll collection through RFID tags and no stoppage of vehicles) - 1200veh/hour.
9.	Toll collection System	Electronic toll collection.
10.	Pavement	Concrete pavement shall be provided in the toll plaza area including tapering zone.
11.	Traffic sign	Shall be provided as per clause 10.4.15 of IRC: SP:84-2019 and IRC:67:2022.

S. No.	Elements	Specification
12.	Road marking	Lane marking, diagonals, chevron marking, etc. shall be in accordance with IRC:35:2015.
13.	Lighting	• Interior Light – Average 200 to 300 lux. • Exterior lighting. 1. High mast lighting- height 30m. 2. Highway lighting-Minimum 40 lux and minimum 500m length on both side approach. Steel welded tubular pole of 10m height and with 2m overhang, sodium vapor/LED lamp 200-250 watt, 50m staggered spacing.
14.	Fire Fighting System	Toll plazas have firefighting equipment, including smoke detector and auto visual alarm.
15.	Toll Plaza Complex	Toll plaza complex shall have the following facilities: 1. Office Space for Manager, Cashier and Other staff. 2. Separate rooms for TV monitor, meetings toilets and for the sale of passes, smart cards, on board units and public interaction. 3. The building shall have a strong room for keeping the cash and a garage to accommodate the security van. 4. There shall be parking space in the same campus for vehicles for the staff and worker.

6.1.15 Project Facilities

Provision shall be made for the facilities like pedestrian facilities, street lighting (Urban areas), cattle crossings, bus bays with shelters, truck lay byes and traffic/Medical Aid Posts, Service Areas, Safety/ Noise Barriers as per IRC:SP:84-2019 “Manual of standard and specification for 4-laning of highways” and other relevant IRC Codes.

S. No.	Elements	Specification
1.	Street Lighting	• Location where lighting is to be Provided (as per Clause 12.5.3 of IRC: SP:84-2019). ➤ Toll plaza area. ➤ Rest area. ➤ Truck lay-bye. ➤ Grade Separated Structures, interchanges, flyover, Underpasses and overpasses. ➤ Built-up area.

S. No.	Elements	Specification
2.	Truck lay-bay	- Location and size (as per Clause 12.6.2 of IRC: SP: 84- 2019). ➤ Length of truck lay-bay shall be 100 m with 7 m carriageway, 1 m separator with 0.5 m shyness and 2.0m width of raised footpath. - Facilities (as per Clause 12.6.3 of IRC: SP:84-2019). ➤ Paved Parking. ➤ Rest areas with toilets, drinking water. ➤ Telephone. - Lighting (as per Clause 12.6.4 of IRC: SP:84-2019). ➤ 50 m length of project highway on its either sides shall be illuminated at night to provide a minimum illumination of 40 lux.
3.	Bus bays and Bus shelter	- Location (as per Clause 12.7.2 of IRC: SP:84-2019). ➤ Length of bus bay/shelter 15/30/45m shall be adopted with 7m carriageway width and 3m island width. ➤ Should not locate on horizontal curves or at summit of vertical curves. ➤ The bus bay shall not be located too close to the road intersection. ➤ Bus bay shall be provided on both sides of the project highway in each direction. ➤ The bus bay shall be provided with a shelter for passenger. - Drainage (as per Clause 12.7.5 of IRC: SP:84-2019). ➤ Proper cross slope. ➤ Suitable Kerb gutter. ➤ Adequate drainage for steps and pedestrian area. - Road marking (as per Clause 12.7.6 of IRC: SP:84-2019). ➤ The road marking at bus bay should be given as per IRC-35 and per Clause 12.7.6 of IRC: SP:84-2019. - Lighting (as per Clause 12.7.8 of IRC: SP:84-2019). ➤ The entire bus bay area shall be provided with lighting (minimum illumination of 40 lux).
4.	Facilities at toll plaza	- Medical Aid posts as per Clause 12.11 of IRC: SP:84-2019. - Highway Patrol Unit(s) (As per Clause 12.10 of IRC: SP:84-2019). - Emergency Medical Service (as per Clause 12.11 of IRC: SP:84-2019). - Crane Service (as per Clause 12.12 of IRC: SP:84-2019). - Communication System shall be provided as per clause 12.13 of IRC: SP:84-2019. - Advanced Traffic Management Systems As per Clause 12.14 of IRC: SP:84-2019. - Operation and Maintenance Center as per Clause 12.15 of IRC: SP:84-2019.

6.1.16 Traffic Control and Safety Devices

Traffic control and Road Safety Devices shall be proposed for safety of road users as per section 9 of IRC: SP:84-2019 “Manual of standard and specification for 4-laning of highways”, in consideration with IRC-67, IRC-35.

Highway drainage design

Adequate drainage is primary requirement for the maintaining structural soundness and functional efficiency pavement structure including subgrade must be protected for any ingress of water. Roads are constructed with two types of drainage system surface drainage and subsurface drainage. This drainage shall be provided for project highway as per IRC: SP: 42:2014.

6.2 DEVELOPMENT OF DESIGN STANDARDS FOR BRIDGES/ STRUCTURES

6.2.1 Introduction

The main design criteria shall be to evolve design of a safe structure having good durability conforming to the various technical specifications and sound engineering practices.

The design standards for bridges are based on recommendations regarding loading and material strength characteristic contained in the current bridge design practices and are contained in the relevant IRC standards. The aspects regarding geometry and structural design of various components and settlement effects form the main considerations for design of bridges.

The design of bridges is based on various parameters and data such as design discharge of stream, HFL, scour level, characteristic of stream/river, sub-soil type, selection of site, etc. The selection of proper bridge site, computation of design discharge, bearing capacity and characteristic of soil are required to conceptualize a new bridge. The carriageway width, footpaths, crash barrier are designed as per applicable MOSRT&H & IRC guidelines. Based on all these data, type of bridge, length of bridge, height of bridge, type of foundation (whether shallow or deep) is decided. The various data required for design of structures, method of computation of these data and parameters of bridge design are given below.

Hydraulic and Hydrological investigations play an important role in design of bridges. The objective of this investigation is to plan the structures so that the bridge / CD structure should pass safely the design discharge without disturbing the regime of river. The CD structure should not obstruct the flow of river and the length of bridge should be equal to regime width of the river as given by the formula for regime condition in IRC: 5. it is necessary to assess correctly the discharge of river, HFL, scour depth, flood frequency, intensity of rainfall and average velocity of flow.

The design discharge for which the waterway of bridge is to be designed is generally the maximum flood discharge on record for a period of 100 years for all Bridges. In case where

the discharges are not available it will be calculated by various rational formulas and methods given in literature.

6.2.2 Width of Structures

Width of structures are as per latest applicable Manual of specifications (i.e. As per IRC: SP: 84-2019 for 4 laning section) & latest amendments in this regard are followed. However, the final decision for the width of structures shall also be deliberated with IAHE.

6.2.3 Design Assumptions

Following table indicates the standards used in the design.

Table 6.9: Design Standard

S. No.	Design Figure		Standard
1	Cover (As per condition of exposure)		
	i	Superstructures	40mm
	ii	Crash Barrier	50mm
	iii	Substructures	50mm
	iv	Pre-stressing cable duct	75/90mm
	V	Pre-cast elements	40mm
	vi	Foundations	75mm
2	Grade of Steel		
	i	HYSD bars	Fe500
	ii	Structural Steel	Fe490
3	Grade of Concrete		
	i	Pre stressed Concrete Girder	M45/M50
	ii	RCC Deck slab over PSC Girder	M45/M50
	iii	RCC Voids slab /RCC girder	M 35
	iv	RCC Deck Slab over RCC Girder	M35/M40
	v	RCC Box type structure/ culverts	M30/M35
	vi	Pier and Pier Cap	M30/M35
	vii	Bearing Pedestal	M40
	viii	RCC Abutment, Abutment cap, Retaining Wall, Return Wall, Dirt wall	M35
	ix	Open foundation	M35
	x	Crash Barrier	M40

S. No.	Design Figure		Standard
	ix	Approach slab	M30
	x	Leveling course	M15
4	Dead load- (unit wt.)		
	i	Pre-stressed Concrete	2.5 T/m ³
	ii	Reinforced Concrete (RCC)	2.5 T/m ³
	iii	Plain Cement Concrete (PCC)	2.5 T/m ³
	iv	Steel	7.8 T/m ³
	v	Wearing Coat	2.2 T/m ³
5	Live Load		
	i	Footpath	400 Kg/m ² (Rural area)
			500 Kg/m ² (Urban area)
	ii	c/w 5.3m to 9.6m	One lane of class 70R or Two lane of Class A
	iii	c/w 9.6m to 13.1 m	One lane of class 70R for every two lanes with one lane of class A on the remaining lane or 3 lanes of class A
	iv	c/w 13.1m to 16.6m	One lane of Class 70R for every two lanes with one lane of Class A for the remaining lanes, if any, OR one lane of Class A for each Lane
6	Impact		
	Concrete Bridges		
	i	for Class A	For Concrete bridges- 4.5/(6+L) For Steel bridges- 9/(13.5+L)
	ii	for Class AA, 70 RT & Class 70 RW (Concrete Bridges)	Upto-9m <u>For Tracked</u> -25% for span up to 5m and linear reducing to 10% for span

S. No.	Design Figure		Standard
			upto 9m. <i>For wheeled</i> -25% More than 9 m <i>For Tracked</i> -10% for span between 9m to 40m. As per curve for span more than 40m. <i>For wheeled</i> - 25% for span upto 12m and as per curve for span more than 12m
	iii	for Class AA, 70 RT & Class 70 RW (Steel bridges)	<i>For Tracked</i> -10% for all spans <i>For wheeled</i> - 25% for span upto 23m and as per curve for span more than 23m
7	Wind Load		
	i	As per basic wind speed and Type of the structure	
8	Horizontal Forces due to water current		
	i	Case-I	Parallel to pier
	ii	Case-II	At inclination to the pier
9	Longitudinal forces		
	i	Case-I	In case of single lane and two lane 20% of first train load plus 10% of load of succeeding train or part thereof
	ii	Case-II	In case of bridges with more than two lane braking force for two lane plus 5 % of the loads on the lanes in excess of two
10	Centrifugal Forces		$W \times V^2 / (127 \times R)$
11	Buoyancy		
	i	100 % buoyancy for stability check	
	ii	15 % buoyancy for design	
12	Earth Pressure		
	i	Ka	0.2794

S. No.	Design Figure		Standard
	ii	Phi	30°
	iii	Delta	20°
	iv	Earth pressure at rest will be considered to be acting on the vertical walls of the RCC Box	
13	Temperature		
	For bridge having difference between max and min air shade temperature-		
	>20 degree C	Mean of Maximum and Minimum air shade temperature +, - 10°C whichever is critical	
	<20 degree C	Mean of Maximum and Minimum air shade temperature +, - 5°C whichever is critical	
14	Seismic force		
	i	Zone-III	Major Structures shall be designed for Seismic forces as per provision in IRC:6-2014
15	Expansion Joints		
	i	Filler type	RCC Slab
	ii	Asphaltic plug	RCC Box
	iii	Strip Seal Type	For RCC/ PSC/ RCC voided slab type superstructures
16	Bearing		
	i	Pot PTFE	RCC Voided/ PSC Precast girder/ PSC Box/ RCC Girder
	ii	Elastomeric/ neoprene	RCC Girder type small minor bridges/ GS structures
17	Wearing Coat		As per MoRT&H 5 th Revision
18	Pre stressing Steel		12T13 or 19T13
19	Sheathing		Corrugated HDPE
20	Margin in Material (FOS)		
All critical sections shall be checked for stresses under various load combinations. A suitable margin (preferably 8-10%) shall be there between maximum stress and allowable stress in concrete as well as reinforcement in the final design.			

6.2.4 Design Codes

This section below outlines the standards adopted for the design of the structures which includes Culverts, Minor Bridges, Major Bridges and PUPs/VUPs & Flyovers.

The IRC codes/Standards/Act, MoRT&H Publications & BIS Publications is being followed in the project. Design of all proposed structures is in accordance with the provisions of the following IRC Codes:

Table 6.10: List of IRC Codes

Code	Description
IRC:5-1998	Standard Specification & Code of practice for Road Bridges. Section – I General Features of Design (Seventh Revision)
IRC: 6-2014	Standard Specification & Code of practice for Road Bridges. Section – II Loads & Stresses (Revised Edition)
IRC: 112-2011	Codes of Practice for Concrete Road Bridges
IRC: 22-2008	Standard Specification & Code of practice for Road Bridges. Section – VI Composite Construction (Second Revision)
IRC:78-2014	Standard Specification & Code of practice for Road Bridges. Section – VII Foundation & Substructure (Revised Edition, with all amendment up to December 2013)
IRC: SP: 64-2005	Guidelines for the Analysis & Design of Cast-in-place Voided Slab Superstructure
IRC: SP: 84-2019	Manual of Specifications & Standards for Four Laning of Highways (second Revision)
IRC: 83-1999 (Part-I)	Standard Specification & Code of practice for Road Bridges. Section – IX Bearings, Part-I Metallic Bearings (First Revision)
IRC: 83-1987 (Part-II)	Standard Specification & Code of practice for Road Bridges. Section – IX Bearings, Part-II Elastomeric Bearings
IRC: 83-2002 (Part-III)	Standard Specification & Code of practice for Road Bridges. Section – IX Bearings, Part-III POT, POT-CUM-PTTE, PIN & Metallic guide bearings.
IRC: SP:66-2005	Guidelines for design of continuous bridges
IRC: SP:67-2005	Guidelines for use of external & unbounded pre-stressing tendons in bridge structures.
IRC: 89-1997	Guidelines for Design & Construction of River training & control works for road bridges.
IRC: SP:13-2004	Guidelines for the Design of small Bridges and Culverts

Code	Description
IRC: SP:33-1989	Guidelines on supplemental Measures for Design, Detailing & Durability of Important Bridge Structures.
IRC: SP:37-1991	Guidelines for evaluation of load carrying capacity of Bridges.
IRC: SP:40-1993	Guidelines on Techniques for strengthening and rehabilitation of Bridges.
IS: 456 - 2000	Plain and Reinforced Concrete – Code of Practice

Whenever IRC codes are silent, relevant BIS codes shall be followed. In case where even BIS codes are silent, other suitable international codes of practices like BS, AASHTO and EURO codes shall be adopted.

6.2.5 Design Considerations

The designs for structures are based on the following considerations:

- 1) The overall width of Bridges & Grade separated structures for main carriageway conforms to Manual of Specifications.
- 2) Foundation of proposed bridge shall be based on Geotechnical investigation.
- 3) Foundation of existing bridges/ culverts proposed to be widened shall be the same as per the existing bridge/ culverts.
- 4) The type of superstructure for bridges are proposed considering various factors such as suitability, ease of construction and maintenance, speed of construction, available formwork and standardization.
- 5) Analysis & Design of all type of superstructure to be submitted in DPR (considering individual bridge on case-to-case basis) shall be done as per standard codes of practice.
- 6) Also, Detail Analysis & design of the different components of Substructure and foundation for the loads transferring from super structure & other loads shall be done as per standard codes of practice.
- 7) Construction technique shall aim to strike a balance between ‘highly mechanized’ & ‘labor intensive’ approach. A semi-mechanized approach shall be desirable.
- 8) Aesthetic considerations to suit the surroundings will be considered while designing the structures.

6.2.6 Design Methodology

6.2.6.1 Scheme for selection for appropriate type of structure

The following types were explored considering on case-to-case basis to finalize the type of structures:

- a) Simply supported structures
- b) Continuous Structures with bearing support
- c) Integral Structures

a) Simply supported structures

Easier to construct & due to simple construction & installation technique, such structures are mostly suitable for culverts and minor bridges within short and medium span range. They are also suitable in situations where the sub-soil condition is poor and not conducive for continuous structures where differential settlement may be large. There are, however, some disadvantages of using simply supported bridges in case of long multiple span bridges as they require considerable number of expansion joints, which constitutes a serious inconvenience and entail continuous costs during operation.

b) Continuous Structures

Provision of structures can be explored as such Structures are preferred in case of long and multiple span bridges/ structures. These permit construction of longer spans in relation to the dead weight, thus reducing the number of expansion joints, piers and bearings.

c) Integral Structures

Bridges constructed without any expansion joint (between spans or between spans and abutments) and without any bearings are called integral bridges. In its simplest form, an integral bridge may be viewed as a box culvert, where the road surfaces are continuous from one approach embankment to the other, providing better riding quality & reducing initial cost as compared to convention expansion joint bridges

6.2.6.2 Selection of Type of superstructure

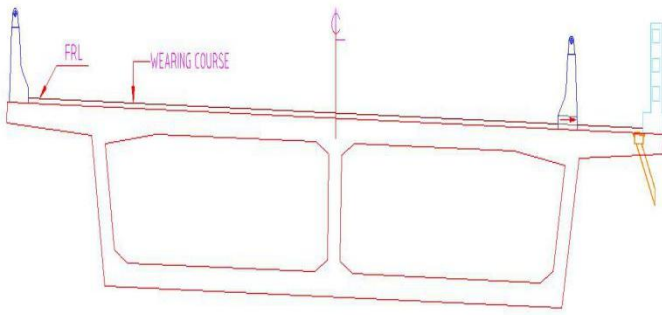
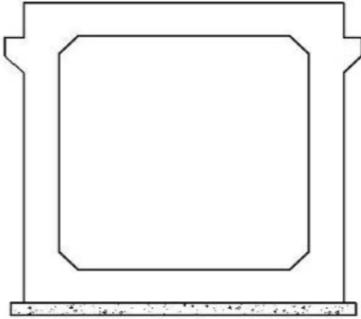
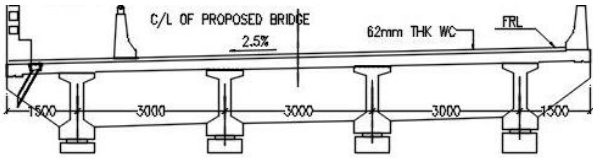
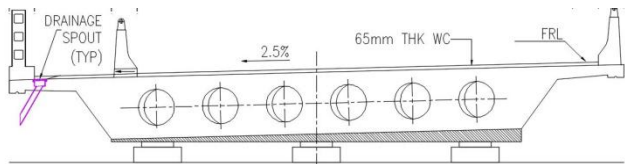
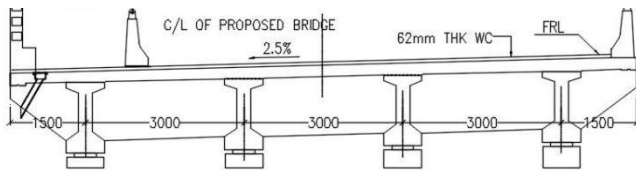
The types of Superstructures that are explored in project stretch are summarized in following table based on their desired span length & curve radius (if, any):

Table 6.11: Selection of type of Superstructure

Span range (m)	Type of Superstructure
Upto 12.0	RCC Box (For single span non skew structures)
Upto 12.0	RCC Slab (For single span skew structures)
12.0 to 20.0	RCC Girder (for Minor Bridge without curves)
12.0 to 22.0	RCC Voids slab (for structures with sharp curves)
20.0 to 40.0	PSC Girder (for structures without curves)
22.0 to 40.0	PSC Box Girder (for structures with sharp curves)

The type of superstructure is proposed based on its cost effectiveness, suitability of construction, installation technique, better riding quality, design efficiency, available formwork and site condition. Various type of Superstructures used is as follows (**Table 6.12**):

Table 6.12: Type of Superstructure

Cross-section	Type of Superstructure
	PSC Box Girder (One cell/Multiple cell) for following span conditions: 1. More than 40.0m (for structures with large/ no radius. 2. Between 22.0 to 40.0m (for structures in curves).
	RCC Box for square Span Length upto 12.0m for VUPs, PUPs, LVUPs & Culverts. (RCC Solid Slab may also be used for culverts & VUP with same skew span length)
	PSC Girder for following span condition: 1. Between 20.0 to 40.0m (for structures with large/ no radius.
	RCC Voids Slab for following span conditions: 1. Between 12.0 to 22.0m (for structures in curves).
	RCC Girder for following span condition: 1. Between 12.0 to 20.0m (for structures not in curves).

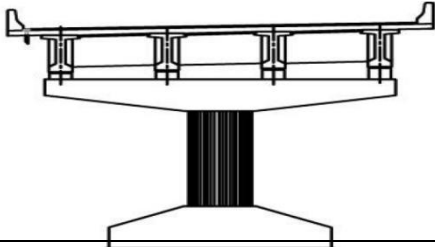
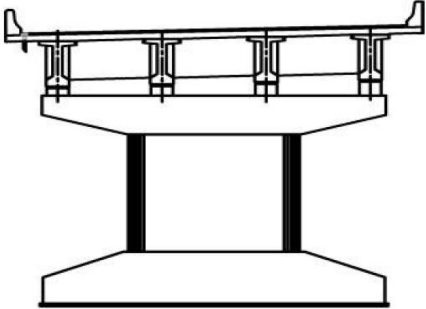
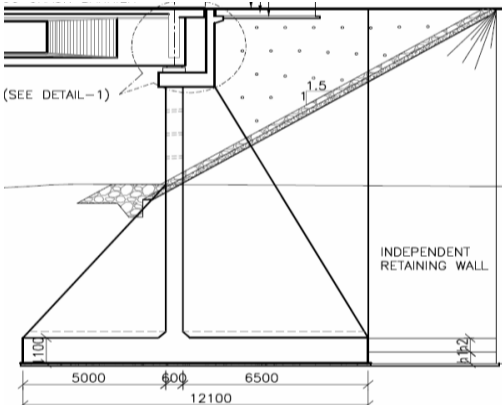
6.2.6.3 Selection of type of Sub-Structure:

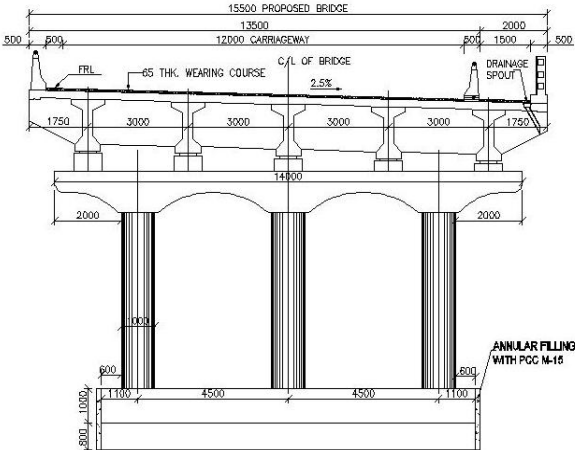
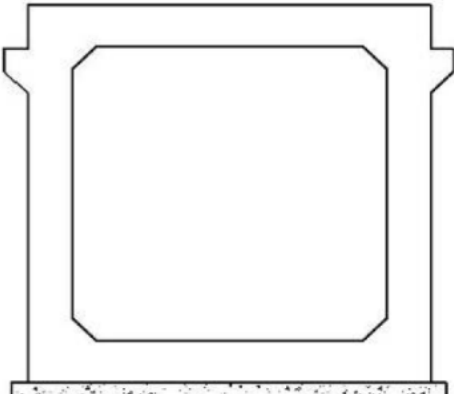
Plate/Wall type of piers are considered for bridges on river/stream. Alternatively single circular piers with cantilever pier cap are also explored. Piers shall be placed parallel to the flow direction under HFL condition. Suitable cut waters shall be provided at the ends to ease the water current force.

The possibilities of Circular/Portal type of Pier are also considered for considering the cost implications.

The abutments in case of bridges on streams are of solid cantilever type having a wall face in front. Counterfort type Abutment is also explored for cases where the reduced section dimensions are desired for greater heights. Thus, various type of Sub-structure explored are also mentioned as below in **Table 6.13:**

Table 6.13: Type of Sub-Structure

Cross-section	Type of Superstructure
	Single Pier Cantilever type
	Wall Type Pier
	Counterfort Abutment (For structures desired with greater height & reduced section dimensions)

Cross-section	Type of Superstructure
	Portal type sub-structure
	Precast RCC Box (Suitable for Culverts, PUPs, VUPs)

6.2.6.4 Appropriate Type of Foundation

The project stretch lies within the rocky terrain, considering which, the Safe bearing capacity of sub-soil seems to be reasonably good and scour depth shall be low. Thus, open foundation with isolated footing is a potential option. However, in situations where above option is not feasible, pile foundation is considered.

6.2.7 Material/ Durability & Maintenance Considerations

6.2.7.1 Concrete

The Grade of Concrete considered is as per design requirement & mentioned in execution drawings for each component of the structure. Cement & Water Content is as per mix design requirement; however, minimum grade of concrete, minimum cement content & maximum water cement ratio conforms to IRC: 112-2011 for moderate condition. Modulus of elasticity of concrete is be considered as per the Table 6.5 of IRC: 112-2011.

6.2.7.2 Reinforcement

Deformed or TMT reinforcement bar conforming to IS: 1786 are considered for components of the structures. The reinforcement grade shall be Fe500.

6.2.7.3 Pre-stressing Steel

For Pre-stressing 7ply strand cables conforming to Class 2 of IS: 14268 (Low Relaxation Strands) are considered so as to reduce losses due to relaxation. Pre-stressing Steel shall be subjected to acceptance tests prior to actual use on the works (guidance may be taken from BS: 4447). The Modulus of elasticity (as per the acceptance tests) conforms to the design value which shall be within a range not more than 5% between maximum & minimum.

Many Cables with different arrangements of wires & strands and different methods of anchorage are available as pre-stressing steel. So, type & size of cable & methods of anchorage shall be decided on the basis of design requirement. Pre-Stressing steel conforms to Clause No. 18.3.1 of IRC 112 -2011.

6.2.7.4 Sheathing

The duct or sheath for cables to be used is considered to be of Corrugated HDPE/Galvanized having coefficient of friction and wobble coefficient per meter length of steel as specified in table No. 7.1 of IRC 112-2011. The thickness of sheathing is as specified in clause 13.4.2 & 13.4.3 of IRC: 112-2011 for metal and HDPE sheathing, respectively.

6.2.7.5 Bearings

Bearing for Structures shall be designed to transmit all the loads and appropriate horizontal forces.

Elastomeric bearings is considered for short span simply supported superstructures (RCC or PSC Pre-cast/ cast-in-situ Girders) to accommodate translation movements in any direction and rotational movements in any axis by elastic deformation. They are not in tension or when rotation is high and vertical load is low. Elastomeric bearings shall be designed as per IRC: 83 (Part II) and shall conform to MoRTH's Specifications for Road & Bridge Works (5th Revision). Tar paper bearings are used for small span RCC solid slab superstructures.

Pot fixed/Pot PTFE sliding bearings are proposed for superstructures (RCC or PSC Pre-cast/ cast-in-situ Girders/ Box Girders/ RCC Voids slab). The design of the POT/ PTFE bearing shall be done by the manufacturer conforming to the provisions of material as well as design parameters stipulated in IRC: 83 (part-III). The same shall be got approved by the engineer. The forces, movements and rotation etc shall be provided by the designer of the project on the format given in appendix-1 of IRC: 83 (part-III). In support of quality

assurance, acceptance specification given in clause 928 of IRC: 83 (part-III) shall be followed.

6.2.7.6 Crash Barriers

Suitably designed crash barriers shall be provided to safeguard against errant vehicles. According to their applications, Normal Containment Crash barrier are considered for all structures (bridges, underpasses & Culverts etc.). The Design Loading for the Crash Barriers conforms to Clause 206.6 of IRC: 6-2014. The typical detail of the crash barrier is provided in the **figure 6.17**.

6.2.7.7 Expansion Joints

Expansion joint to be provided is considered as per IRC: SP: 69-2005 depending upon the anticipated expansion/ contraction. These conform to Section 2600 Technical Specification of MORTH. Types of expansion joint based upon the length of span and movements are as given below:

Table 6.14: Type of Expansion Joints

S. No.	Span	Expansion Joints
1	For RCC Slab type structures up to 12 m span only	Filler type expansion joints
2	For RCC Box type structures	Asphaltic Plug type
3	For all other bridges having span longer than 12 m and where movements are up to $\pm 70\text{mm}$	Elastomeric Single Strip Seal type expansion joints
4	and where movements are up to $\pm 70\text{mm}$	Double strip Seal/Modular type expansion joints

6.2.7.8 Wearing Course

As per MoRTH Specifications, 50mm/65mm thick wearing coat is considered (comprising of 50mm BC in single layer or Mastic in single layer/ 40mm BC overlaid with 25mm Mastic asphalt).

6.2.7.9 Approaches

The approaches on the either side of the Grade separated structures are considered to be of earth retaining structures or of conventional embankments as per the site conditions. The

approaches on the either side of the Bridges would have slope protection as per applicable manual of specifications.

6.2.7.10 Approach Slab

Reinforced concrete approach slabs, 3.5 m long and 300 mm thick, in M30 grade concrete at either end of the bridge, will be provided. One end will be supported on the reinforced concrete bracket projecting from the dirt wall and the other end resting over the soil, in accordance with the guidelines issued by MoRT&H. A leveling course, 150 mm thick, in M-15 grade concrete will be laid under the approach slabs. As per IRC SP: 13, Approach Slab for Slab & Box Culverts is dispensed with.

Typical shape and dimensional details of Approach Slab are given in **Figure 6.17**.

6.2.7.11 Drainage Spouts

Drainage spouts is considered in accordance with MOST standard plans. The minimum spacing kept preferably is 5.0m c/c which may be adjusted to suit span length. The drainage spouts at Bridge are proposed with free down fall. Typical shape and dimensional details of Drainage Spouts are given in **Figure 6.17**.

6.2.7.12 Weep Holes

Weep holes are considered with 100 mm dia AC/PVC pipe for plain/reinforced concrete abutment, wing wall and return walls etc. Weep holes extend through the full width of concrete with slope of about 1 vertical: 20 horizontal towards the draining face. The spacing of weep holes is generally be 1.0m in a staggered manner or as shown in the drawing with the lowest weep hole at about 150 mm above the low water level or ground level, whichever is higher.

6.2.7.13 Protection Works

For bridges with raft foundations or in soil, protective flooring, curtain wall and apron are considered for both up-stream and down-stream side as per IRC SP-13/MOST. In case of rocky strata, the same is dispensed with.



6.2.8.1 Dead Loads



6.2.8.2 Superimposed Load

Superimposed Dead load consists of load due to Wearing coat (surfacing coat), crash barrier and foot path with hand rails. Unit weight for superimposed dead load is in conformity with IRC: 6-2014 & as indicated in Design Assumptions (**Table 6.9**) mentioned earlier. Loads corresponding to the dimensions given for bridge furniture details in IRC: 5 are also considered as SIDL for design of structure.

6.2.8.3 Live load

Live Load Combinations specified as per IRC: 6-2014 are considered for New Structures. Single Lane of Class 70R/ 2 Lane of Class A with Footpath/ 3 Lanes of Class A/ Single Lane of Class 70R + Class A loading/ 2 Lane of 70R/ Class A for each Lane (whichever producing severe effect) are considered in design with an appropriate Impact Factor. Reduction in longitudinal effect for three-lane loading is also considered as per Clause 211 of IRC: 6-2014. Also, as per Amendment released for IRC: 6-2014 in January 2014, IRC class Special Vehicle (SV) loading (used for stator units, turbines, heavy equipment & machinery) shall also be considered for analysis.

6.2.8.4 Differential Settlement

If the riding quality permits, clause 706.3.2 of IRC: 78 -2014 specify that the calculated differential settlement between the foundations of simply supported span shall not exceed $L / 400$ of the distance between the foundations, where L is distance between two foundations. In case of structure sensitive to differential settlement such as continuous structures, the value of differential settlement is taken as 10 mm.

6.2.8.5 Temperature Gradient

Temperature forces for calculation of bearing movement and for the design of expansion joint are considered as per clause 215 of IRC: 6-2014. The design will be based on the range of effective bridge temperature at the site location of the structure. The temperature gradient for stress calculation of all structure members is considered as per the clause 215.3 of IRC 6-2014. In context, following parameters shall be used in line with the mentioned clause:

Coefficient of thermal expansion: $12 \times 10^{-6}/^{\circ}\text{C}$.

Highest Maximum Temperature = 45.0°C .

Lowest Minimum Temperature = -7.50°C .

Total Variation in temperature = $+45.0 - (-7.5) = 52.5^{\circ}\text{C}$.

Mean Variation in of temperature = $52.5/2 = 26.25^{\circ}\text{C}$.

Thus, as per clause 215 of IRC: 6-2014, the structures (when effectively restrained) are

designed for a temperature range considering Mean of minimum or maximum air shade temperature $\pm 10^{\circ}\text{C}$, whichever is critical

An effect of distribution of temperature across the deck depth is considered in design of superstructure. The temperature has influence on the movement of expansion joints as well as on bearings. The temperature variation and effect of rise and fall takes place over a season and hence the long-term value of Modulus of Elasticity is considered in the analysis.

6.2.8.6 Longitudinal Forces

As per clause 211 of IRC: 6-2014, longitudinal forces arising due to Tractive Effort, Braking Force and Frictional Resistance offered to movement of free bearings are considered in design of components of bridges.

6.2.8.7 Centrifugal Forces

For the road bridges situated on a curve, centrifugal forces shall be considered as per the provisions of Cl 212 of IRC: 6-2014.

6.2.8.8 Seismic Forces

As per clause 219 of IRC: 6-2014, the Project Stretch falls in Seismic Zone III. The seismic coefficient is considered as per the Importance factor of 1.5 for Structures. Response reduction factor conforms to Clause 219.5.5 of IRC: 6- 2014.

Design seismic forces for substructure and bearings conform to the recommendations of IRC for this seismic zone. Applicability of seismic forces for the design of bridges is as per clause 219.1 of IRC-6: 2014.

6.2.8.9 Differential Shrinkage & Creep

Creep and Shrinkage strain considered are as per Clause 6.4.2.7 and 6.4.2.6 of IRC: 112-2011. This strain has influence on construction sequence, movement of expansion joints and bearing movement apart from loss of prestress force.

6.2.8.10 Water current forces

Water Current Forces considered are as per clause 210 of IRC: 6-2014. The structures shall be designed for a variation of 20 degrees w.r.t to orientation of pier.

HFL, velocity of flow, scour depth has been taken as per past data received and hydraulic calculations. On piers parallel to the direction of water current, the intensity of pressure is given by following equation.

$$p = 52 K V^2$$

Where,

p = intensity of pressure in kg/m^2

K = a constant, value depends on shape of pier

V = velocity of current at point where pressure intensity is to be determined in m/s. (which is zero at the point of deepest scour and $\sqrt{2}$ times maximum mean velocity at the free surface).

6.2.8.11 Hydrodynamic forces under seismic condition

In addition to other inertial forces acting on the structure, Hydrodynamic forces conform to IS: 1893.

6.2.8.12 Wind Forces

Wind Forces conform to clause 209 of IRC: 6-2014, acting perpendicularly to the structure. Drag Coefficient, Gust Factor and Lift coefficient considered accordingly.

6.2.8.13 Buoyancy forces

Full buoyancy (100%) has been considered for checking the stability of foundations. For checking stresses of the substructure components, 15% pore pressure uplift is considered in the design.

6.2.8.14 Earth pressure

As per the Clause 214 of IRC: 6-2014, Structures that are designed to retain earth fills are proportioned to withstand earth pressure calculated in accordance with the Coulomb's theory with point of application at an elevation of 0.42 of the height of the wall above the base. A Live Load Dynamic Surcharge equivalent to 1.2m height of soil above road way is considered for the lateral earth pressure calculation. Structure Stability is checked for both, sliding & overturning as recommended by IRC.

6.2.8.15 Other Loads

The loads, which are not mentioned in above Clause (like Vehicle collision loads etc), are as per IRC: 6-2014.

6.2.8.16 Load Combinations

The various load combinations are considered as per Table 1 of IRC: 6 – 2014.

All members are supposed to sustain safely the IRC critical combination of various loads and forces that can coexist. Various load combinations as specified in Annexure B of IRC-6:2014 with relevant load factors and increase in permissible stresses are considered in the design as per IRC: 6-2014, IRC: 22, IRC: 24, IRC: SP: 64 and IRC:78-2014.

6.2.8.17 Serviceability Limit State

Loads are required to be combined to satisfy the serviceability requirements. The serviceability limit state check is carried out in order to have control on stress, deflection, and crack width. The Rare combination of loads is for checking the stress limit. The Frequent combination of loads is for checking deflection. For crack width calculation, quasi-permanent load combination is considered for pre-stressed with unbounded tendons & RCC member, and frequent combination is considered for pre-stressed members with bonded tendons.

The permissible stresses for pre-stressing and reinforcement conform to chapter 12 of IRC:112-2011.

- Allowable compressive stresses in concrete under rare combination of loads limited to $0.48f_{ck}$.
- Allowable compressive stresses in concrete under quasi permanent combination of loads limited to $0.36f_{ck}$.
- Allowable stresses in reinforcement for reinforced concrete structures under rare and quasi-permanent combination of loads limited to 300MPa.

Crack width calculations are considered as per Cl. 12.3.4 of IRC: 112. The crack width is limited to 0.3 mm for RC members & pre-stressed with unbounded tendons under quasi-permanent load combination and 0.2 mm for pre-stressed members with bonded tendons under frequent load combination as per Table 12.1 of IRC: 112.

6.2.8.18 Ultimate Limit State

Loads are required to be combined to check the equilibrium and the structural strength under ultimate limit state. The equilibrium of the structure is checked against overturning, sliding and uplift. It shall be ensured that the disturbing loads (overturning, sliding and uplifting) is always less than the stabilizing or restoring actions. The structural strength under ultimate limit state is estimated in order to avoid internal failure or excessive deformation. The equilibrium and structural strength are checked under basic, accidental and seismic combination of loads.

6.2.9 Structural Analysis/ Design Methodology

Structural Analysis shall be clearly identified and explained for evolving a comprehensive design methodology, which covers all aspects of design for various parts of the bridges/structures (viz. superstructure, substructure, foundations & bearings).

6.2.9.1 Method of Analysis/ Design for Super Structure

Cast-in-situ/ Pre-cast RCC Box type of Structure

- Analysis of Non-Skew RCC Box type structures considering a slice of unit width (for loads & forces) & modeling the geometry of structure in STAAD Pro. Subsequently, design of section for critical values of loads & combination (applied on the structure) from the output of the analysis. Reinforcement Calculations & Check for Stresses (ULS & SLS case for various combinations) based on acquired results & standard codes of practice.
- Stresses also checked for SLS condition under rare load combination & crack width check for quasi permanent load combination.

Precast & Cast-in-situ RCC Girder type of Superstructure

The Structure having RCC Girder type of Structure (Precast or cast-in-situ) behaves as composite section for all loads since the staging is released after the Slab gains strength. Such Superstructure is analyzed for dead loads, SIDL, Live Loads & other loads using a two-dimensional grillage analogy method.

Skew effect is directly accounted in the grillage model to simulate the actual behavior.

The analysis of the RCC Girder for longitudinal flexure is carried out as below:

- Calculation of effective Flange Width for determination of sectional properties for the longitudinal girders (in accordance with IRC: 112).
- The Longitudinal members of the superstructure (other than skew & curved superstructure) is assigned as torsion less members that are able to resist the loads applied in a plane perpendicular to the plane of assemblage, through bending shear of the members.
- Generation of Grillage Model with longitudinal members along the C/L of the Girder and along the outer edges, along with the Suitable transverse members along the cross beams.
- Separate Calculations of Moments & Shear Forces for Inner & Outer Girders by keeping the load train at a distance of minimum eccentricity from Crash Barrier.
- Calculations of Stresses & Moments at various sections for designing of the Longitudinal Girders (at End of Solid Section, End of tapering Section & at every interval of $L/8$).

- Modeling Transverse Members of the grillage (other than the Cross-Diaphragm) as Slab elements.
- Reinforcement Calculations & Check for Stresses (ULS & SLS case for various combinations) based on acquired results & standard codes of practice.
- Stresses checked for SLS condition under rare load combination & crack width check for quasi-permanent load combination.
- Determining maximum shear stress, by checking the section at a distance equal to effective depth from the face of the Support. Shear Reinforcement calculated at the same section shall be continued up to the support.
- Secondary effects due to shrinkage & creep of concrete for composite structures shall be accounted as per IRC method.

Precast & Cast-in-situ PSC Girder type of Superstructure

The Structure having PSC Girder type of Structure (Precast or cast-in-situ) is dependent on the construction sequence. Such structure is in iso-static condition up to the stage of casting of deck slab & diaphragm. After developing proper bond with the girder, the structure behaves as composite section.

The Design therefore, is done with only the girder section being effective up to the stage of casting of deck slab. Diaphragm & Composite Section are considered for all subsequent loads (i.e. for SIDL & Live Loads).

Such Superstructure is analyzed for dead loads, SIDL, Live Loads & other loads using a two-dimensional grillage analogy method. Self-weight of Girder & Dead Weight Load of Slab is applicable on girder section alone & hence, the design forces for Dead Loads are calculated separately & results are superimposed.

The analysis of the PSC Girder for longitudinal flexure is carried out as below:

- Calculation of effective Flange Width for determination of sectional properties for the longitudinal girders (in accordance with IRC: 112).
- The Longitudinal members of the superstructure (other than skew & curved superstructure) are assigned as torsion less members that are able to resist the loads applied in a plane perpendicular to the plane of assemblage, through bending shear of the members.
- Fixation of Cable length at various sections along the length based on which gross & net section properties along with resultant centroid of strands is calculated at various sections along the length of girder.

- Generation of Grillage Model with longitudinal members along the C/L of the Girder and along the outer edges, along with the Suitable transverse members along the cross beams.
- Separate Calculations of Moments & Shear Forces for Inner & Outer Girders by keeping the load train at a distance of minimum eccentricity from Crash Barrier.
- Calculations of Stresses & Moments at various sections for designing of the Longitudinal Girders (at End of Solid Section, End of tapering Section & at every interval of $L/8$).
- Modeling Transverse Members of the grillage (other than the Cross-Diaphragm) as Slab elements.
- Reinforcement Calculations & Check for Stresses (ULS & SLS case for various combination) based on acquired results & standard codes of practice.
- Determining maximum shear stress, by checking the section at a distance equal to effective depth from the face of the Support. Shear Reinforcement calculated at the same section shall be continued upto the support.
- Effect of Differential shrinkage & creep between pre-cast girder & cast-in-situ slab shall also be considered.

Cross Diaphragm from RCC/ PSC Girder type Superstructure

Design of Cross Girder (i.e. calculation of Bending Moment & required reinforcement) for critical load case is calculated considering both, Jacking condition as well as service condition. Reinforcement Calculations & Check for Stresses (ULS & SLS case for various combinations) are based on acquired results & standard codes of practice. For lifting of span for replacement/maintenance of bearing in any future, it is needful to use jacks located as per design consideration.

Deck Slab for RCC/ PSC Girder type superstructure

STAAD Pro is used to analyze the Deck Slab transversely as a continuous one-way slab (supported on longitudinal girders) with cantilever overhang (on either side) by considering unit width of deck slab along span. Global analysis of Deck slab is also done due to unequal deflection in Girder. The analysis is carried out for various loads (i.e. DL, SIDL & LL). Various design sections are identified & designed for the worst combinations of the loads mentioned earlier. Stresses are then checked for SLS condition under rare load combination & crack width is checked for quasi permanent load combination.

Design of Box Girders (PSC)

- The Bending moment and Shear Forces due to Dead Load, Super Imposed Dead Load and Live Loads worked out based on Simple Beam Theory, considering center to center of bearing as span length.
- To account for torsion, distortion and warping the Live Load bending moments and shear forces increased by 10%.
- In the transverse direction the box is analyzed as R.C.C. section. The box is idealized as a plane frame considering unit width of box. The load intensities due to Live Load are applied on the frame considering the width over which they are dispersed as per I.R.C. codes.
- The concrete stresses at extreme fibers under various stages of loading are checked at all the design sections. Capacities of the sections are also checked for the ultimate moment condition as per provisions of IRC:112.
- For obtaining maximum shear stress, the section at a distance equal to effective depth from the face of the support is checked for ultimate loads and the shear reinforcement calculated at the section is continued up to the support.
- For PSC Box Girders, section cracked or un-cracked in flexure has been decided based on whether the maximum ultimate shear capacity of the sections governs by cracked or un-cracked capacity. At locations where un-cracked capacity governs the relief due to vertical component of pre-stress has been considered.

Design of RCC Voided Slab

The Structure having RCC Voided slab type of Structure is analyzed and designed for loads and forces by modeling the structures in STAAD.pro. Dimensions to be provided conform to IRC: SP-64-2005

- The Bending moment and Shear Forces due to Dead Load, Super Imposed Dead Load and Live Loads is worked out based on Simple Beam Theory, considering center to center of bearing as span length.
- Capacities of the sections are checked for the ultimate moment condition as per provisions of IRC: 112.
- The concrete stresses at extreme fibers and tensile stresses in reinforcement for bending moment/loading under SLS combination are checked at all the design sections as per provision in IRC:112. Stresses of flanges/webs are checked confirming to IRC: SP-64.
- In the transverse direction the voided analyzed as R.C.C. section. The RCC voided is idealized as a plane frame considering unit width of voided slab.

- For obtaining maximum shear stress, the section at a distance equal to effective depth from the face of the support is checked for ultimate loads and the shear reinforcement calculated at the section is continued up to the support.
- Shear check is checked for all critical locations for ultimate loads.

Seismic Design

The Project Corridor falls under the seismic Zone-III. Seismic Analysis is carried out in 2 Steps:

- Carrying out single mode of analysis to obtain the fundamental vibration period of the structure in two orthogonal directions (i.e. Longitudinal & Transverse direction).
- Estimation of seismic forces using the spectrum response, as per IRC: 6-2014.

The calculation for fundamental period is done either by using the simplified expression given in Appendix – D of IRC: 6-2014 or else by modeling the structure in STAAD/Pro and carrying out dynamic analysis.

Vertical seismic coefficient is taken as “two third” of the horizontal seismic coefficient. The vertical seismic is combined with the horizontal seismic in any one direction. The seismic combination to be considered is as follows:

- $\pm SX \pm 0.3SY \pm 0.3SZ$
- $\pm SY \pm 0.3SX \pm 0.3SZ$
- $\pm SZ \pm 0.3SX \pm 0.3SY$

Where SX & SZ are seismic forces in longitudinal & transverse direction respectively, while SY is the seismic force in vertical direction.

6.2.9.2 Method of Analysis/ Design for Sub-Structure & Foundation

The Sub-structure (Abutment/ Pier) is designed to withstand the vertical forces transferring from Superstructure. IRC: 78-2014 Codal provisions is followed in this regard.

The scour to be considered for design is based on mean design flood. In the absence of detailed data, the scour to be considered for design is 0.9 times the maximum design scour depth.

In loose sands or poorly graded sands with little or no fines, vibrations due to earthquake may cause liquefaction or excessive total and differential settlements. Since this project is located in critical seismic zone & hilly region, hence liquefaction effect is not required to be considered.

The dimension of the member & reinforcement is provided as per design requirement & minimum criteria as per latest codal provision.

Open Foundation

Considering the project in hilly & rocky terrain, open Foundation is expected as feasible & shall be proposed in view of rock & safe bearing capacity available at shallow depth. Open Foundation shall be analyzed as per load combinations mentioned in IRC: 6-2014 & shall be designed & checked for bending as per the provisions of IRC: 112 & IRC: 78-2014.

Factor Safety against overturning and sliding for unfactored load combination are given below.

Table 6.15: Open Foundation

S. No.	Load Combination	FOS against overturning	FOS against sliding
1	Basic Combination	2	1.5
2	Accidental/Seismic combination	1.5	1.25

- Stresses are checked for SLS condition under rare load combination & crack width is checked for quasi permanent load combination.
- Seismic forces are increased by 25% for design of Foundation as per IRC:6-2014.

Piers & Pier Cap

The piers are designed for as per the provisions of IRC: 112 & IRC: 78-2014. The design is checked for both, cracked & un-cracked condition.

Pier cap is checked either as a flexural member or as a bracket, depending upon the span/depth ratio. In case it is a flexural member, the bending moments are checked at the face of pier support. Shear force is checked at a distance d_{eff} away from the face of support. In case the pier cap acts as a bracket, the design conforms to provisions of IS: 456 in absence of any specific provision in IRC code for bracket design.

Pier Cap is also checked for bending & shear arising from vertical forces acting on bearings & torsion due to unbalanced vertical loads on bearings.

Analysis, design and detailing will in general conform to the stipulations of relevant IRC codes and good engineering practice.

6.2.9.3 Reinforcement Detailing

- The bar sizes and distance between bars and pre-stressing cable ducts/tendons in accordance with section 15 of IRC: 112-2011.

- Curtailment of bars as per clause 16.5.1.3 of IRC: 112-2011.
- Minimum Reinforcement and Distribution reinforcement in slabs as per IRC: 112
- Minimum shear reinforcement as per IRC: 112-2011.
- Minimum diameter of any reinforcement not less 10mm for open foundation, transverse ties, stirrups and all secondary reinforcement for girder and slab.
- Minimum diameter of any reinforcement not less than 12 mm for pier vertical bar, pier cap main bar, and longitudinal bar in girder.
- Ductile detailing as per chapter 17 of IRC:112.
- Box culverts shall be constructed with individual precast inverted U-shaped sections connected by in-situ base and stitch concrete at deck.

6.2.9.4 Permissible Stresses

The Permissible Stresses in the RCC & PSC members are as per IRC: 112.

The Permissible Stresses in the Composite members & Steel structures considered in design are as per IRC: 22-2008 & IRC: 24-2010, respectively.

Increase in Permissible Stress in steel and concrete due to various load combinations are as per IRC: 6-2014.

6.2.9.5 Software for Analysis and Design

- In house developed programs and spreadsheets for checking stresses and capacity of structural element.
- Structural Analysis: STAAD.pro.



CHAPTER - 7

IMPROVEMENT PROPOSALS

CHAPTER - 7

IMPROVEMENT PROPOSALS

7.1 GENERAL

This chapter deals with brief description of the project highlighting the salient features of the project road. The concept of widening of the road and proposed bypasses/ realignment is discussed. The project proposals like Bus Bays, Truck Lay Bys, Toll Plaza, VUP, Flyover etc. with their locations will also be discussed.

7.2 STUDY OF EXISTING ALIGNMENTS

The project road starts from km 50+925 and end at km 3+720 section of NH-927D from Kalavad to Jamnagar in the state of Gujarat. The Proposed length of the project highway is 47.572 Km, the entire road alignment of Package-2 is passes through Jamnagar district in the Gujarat state.

The existing Carriageway width varying from intermediate lanes to two lanes with passing through congested built-up area. The project corridor comprises intermediate to 4-lane in built-up area i.e. from 6.10m to 14.0m from Km 3+720 to Km 50+925 of total length 47.205 Km. The existing alignment having deficient curve radius including in approaches of bridges.

7.2.1 Right of Way

As per the details obtained from the State PWD, Rajkot and Site road inventory, the existing Right of Way is 24m. The summary of existing ROW along the Project stretch is given in **Table 7.1**.

Table 7.1: Detail of Existing ROW

S. No.	Section in Existing KM	Existing Length (Km)	ROW (m)
1	Km 3+720 to Km 50+925	47.205	24

7.2.2 Carriageway Width

By reconnaissance survey, it is found that existing carriageway width is varying from 6.10m to 14.0m in the built-up area. The stretch wise carriageway width along the project stretch is given in **Table 7.2**.

Table 7.2: Detail of Carriageway Width

S. No.	Existing Location (Km)		Length (Km)	Carriageway width (m)	Remarks
	From	To			
1	50+925	48+800	2.125	6 m to 6.5 m	-
2	48+800	45+200	3.600	14 m	Kalavad Town
3	45+200	3+720	41.480	6 m to 6.5 m	-

7.2.3 Existing Geometry

The geometry deficiency has been observed at many locations along the project highway. There are total 66 curve deficiencies has been observed, which is summarized in **Table 7.3** below and there existing radius are listed in **Table 7.14**.

Table 7.3: Existing Geometry Deficiency

S. No.	Number of Locations	Deficiencies
1	3	Reverse curve with insufficient curve length.
2	13	Radius less than Absolute minimum required.
3	5	Radius less than Desirable minimum required.
4	37	Broken Back Curves with sharp reverse curve.
5	8	Length of curve and transition is not sufficient as per existing deflection angle.

7.2.4 Pavement Condition

The existing pavement surface is flexible type in throughout the length project with earthen shoulders. Paved shoulders are absent in the complete stretches.

The pavement condition is fair to poor in the section between Kalavad and Jamnagar which is only due to inadequate maintenance. During the site visit following defects were generally noted:

1. Cracking (alligator, transverse, longitudinal, edge)
2. Patching
3. Raveling

4. Potholes
5. Edge breaking
6. Depressed shoulders

The surface is poor especially in those stretches where periodic maintenance by the way of renewal has not been done for quite some time. The side drainage is generally available along the project stretch.

The road surface is black topped with SDBC in some portion and with Premix carpet in rest of section. At most of the locations the last overlay was done with SDBC while in some stretches BM was laid under PMC. The Following graph indicating the pavement condition in percentage with respective of distresses were noted.

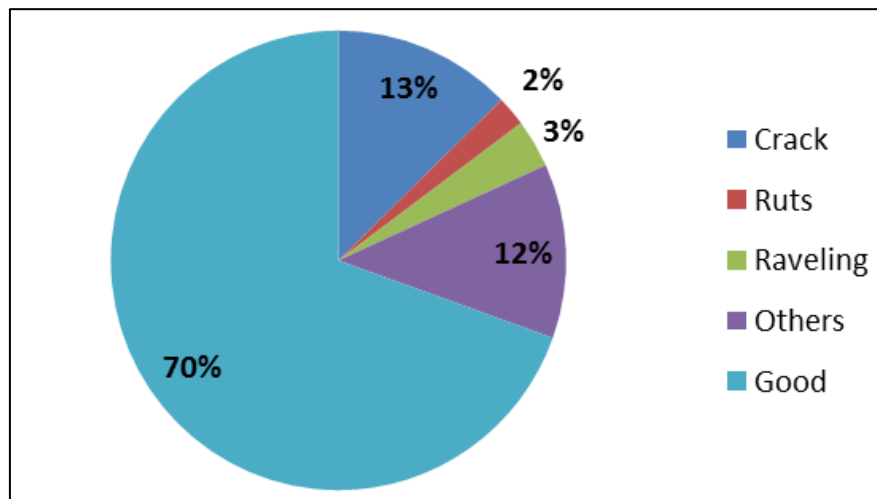


Figure 7.1: Existing Pavement Condition

7.2.5 Terrain and Land Use

7.2.5.1 Terrain

The project highway throughout in length is passes through the plain and rolling terrain.

7.2.5.2 Land Use

Land use pattern along the project corridor is mainly agricultural land and built-up. Barren land and forest area are in very few stretches along the project road.

7.2.6 Design Chainage, Existing Kilometer and Coordinate

The Design Chainage v/s Existing Kilometer has been listed in **Table 7.4** below with easting and northing coordinate.

Table 7.4: Design Chainage vs Existing Kilometer with Coordinate

S. No.	Design Chainage	Existing Km	Easting	Northing
1	0.000 (Bypass start)	Kalawad Bypass	643064.471	2453037.886
2	1+000	Kalawad Bypass	643628.753	2453843.129
3	2+000	Kalawad Bypass	644015.424	2454704.195
4	3+000	Kalawad Bypass	643871.363	2455693.764
5	4+000	Kalawad Bypass	643727.301	2456683.333
6	5+000	Kalawad Bypass	643583.240	2457672.901
7	6+000	Kalawad Bypass	643048.651	2458470.830
8	7+000	Kalawad Bypass	642160.523	2458921.886
9	8+000	Kalawad Bypass	641170.002	2459049.177
10	9+430	Kalawad Bypass End	639825.110	2459393.950
11	10+000	42+362	639504.650	2459861.231
12	11+000	41+361	638851.913	2460615.327
13	12+000	40+341	638201.317	2461356.704
14	13+000	39+358	637878.224	2462301.635
15	14+000	38+364	637290.625	2463059.349
16	15+000	37+351	636547.544	2463699.040
17	16+000	36+341	635808.580	2464370.161
18	17+000	35+430	635171.938	2465078.630
19	18+000	33+783	634478.815	2465771.273
20	19+000	32+807	633781.379	2466484.681
21	20+000	31+799	633508.859	2467434.052
22	21+000	30+786	632870.961	2468177.535
23	22+000	29+788	632197.647	2468912.041
24	23+000	28+764	631305.012	2469233.507
25	24+000	27+730	630391.543	2469628.376
26	25+000	26+758	629417.155	2469832.788
27	26+000	25+770	628676.760	2470409.183
28	27+000	24+635	628100.704	2471218.635
29	28+000	23+640	627458.865	2471983.478
30	29+000	22+630	626747.273	2472678.249
31	30+000	21+655	626536.126	2473641.277

S. No.	Design Chainage	Existing Km	Easting	Northing
32	31+000	20+622	626330.436	2474577.273
33	32+000	19+612	626441.340	2475564.054
34	33+000	18+589	626352.845	2476557.404
35	34+000	17+583	625659.154	2477195.551
36	35+000	16+601	624783.506	2476733.789
37	36+000	15+552	624008.858	2477250.570
38	37+000	14+551	623060.474	2477563.164
39	38+000	13+537	622388.829	2478273.471
40	39+000	12+334	621509.323	2478722.848
41	40+000	11+316	620838.209	2479439.234
42	41+000	10+311	619983.547	2479949.005
43	42+000	9+261	619137.887	2480481.680
44	43+000	8+292	618278.064	2480992.184
45	44+000	7+264	617430.809	2481517.604
46	45+000	6+295	616583.360	2482026.617
47	46+000	5+295	615642.132	2482364.387
48	47+000	4+293	614764.252	2482833.632
49	47+572 (Project end)	3+720	614255.880	2483095.830

7.2.7 Existing Major and Minor Junctions

There are total 21 existing intersection along the project highway. Out of which, 4 no. are four arm junctions and 17 no. are of three arm junctions. There are 4 major intersections, intersecting with National and State highway. Remaining 17 are minor junctions with village / other type of road. The list of major and minor junctions is given in **Table 7.5 & 7.6:**

Table 7.5: List of Existing Major Junctions

S. No.	Existing Km	Type of Intersection	Cross Road Type	Cross Road Leading to		Remarks
				LHS	RHS	
1	46+500	3-Legged	SH-23		Rajkot	In Kalavad Village with 4-lane section
2	45+760	3-Legged	SH-94		Phalla	In Kalavad Village with 4-lane section

S. No.	Existing Km	Type of Intersection	Cross Road Type	Cross Road Leading to		Remarks
				LHS	RHS	
3	11+210	3-Legged	SH		Alyapada	Jambuda Road
4	4+630	4-Legged	SH-25	Dwarka	Morbi	End Point of Project Road

Table 7.6: List of Existing Minor Junctions

S. No.	Existing Km	Side	Type of Junction	Type of Surface	Width of Cross Road (m)	Cross Road Leading To
1	47+500	RHS	T	BT	5.4	Mota Bhadukiya
2	47+300	Both	X	CC	4	Pipaliya (LHS) Sardarbag (RHS)
3	45+515	LHS	Y	BT	3.5	Wavadi
4	44+615	LHS	T	BT	3.7	Wavadi
5	38+710	RHS	Y	CC	3.1	Ranuja
6	31+030	RHS	T	BT	6.3	Varudi Temple
7	28+600	LHS	Y	BT	5.6	Khankotda
8	22+235	RHS	Y	BT	4.2	NaniMatli
9	19+850	RHS	T	BT	3.6	Pasaya
10	18+000	RHS	T	BT	4	Beraja
11	17+465	RHS	Y	BT	3.8	Aliya
12	12+200	LHS	Y	BT	3	Miyathara
13	11+980	RHS	T	CC	3.3	Vijrakhi
14	10+345	Both	X	BT	5.3	Suwarada (LHS) (RHS)
15	8+700	RHS	T	CC	5.8	I.O.C. Ltd
16	6+245	Both	X	CC & BT	3.9	Theba (LHS) (RHS)
17	4+630	Both	X	BT	20.5	Khambhaliya (LHS) & Dhrol (RHS)

7.2.8 Built-up Area/ Urban Area

The major built-up area has been countered along the project road is listed below

Table 7.7: Built-up Area/ Urban Area along the Existing Alignment

S. No.	Existing KM		Total Length In Km	Built-Up Area
	From	To		
1	45+180	48+875	3.695	Kalavad village
2	39+200	38+500	0.700	Haripar Village
4	12+250	11+900	0.350	Vijarakhi Village
5	9+920	10+650	0.730	Survada Village
6	6+440	5+760	0.680	Theba village

7.2.9 Utilities

Utilities like electric line, OFC, Gas / Oil Pipe line, High Tension Line etc are running along/ across the project road. The High tension line has been crossing at 6 location along project highway listed in **Table 7.8**. The crude oil/gas pipe line has been crossing at existing Km 10+000 and Km 12+800.

Table 7.8: High Tension Line Crossing

S. No.	Existing Km	S. No.	Existing Km
1	5+400	2	7+500
3	10+800	4	26+000
5	28+020	6	39+820



Figure 7.2: HT Pylon and HT Line at Km 26+000



Figure 7.3: IOCL Crude Oil Pipe Line Near Km 10+000



Figure 7.4: Cairn's Crude Oil and Gas Pipe Line Near Km 12+800

7.2.10 Road Side Furniture

The Kilometer stones and 200m have been found almost all along the project highway. The many boundary stones are missing along the project highway. The Kilometers stones are marked as SH-26 (State Highways).

7.2.11 Details of Existing Drain along the Project

The existing earthen drainage has been found at following location listed in **Table 7.9** along project road. There is no line drain along project highway.

Table 7.9: Detail of Existing Earthen Drain

S. No.	Existing Km (LHS)			Existing Km (RHS)		
	From	To	Length	From	To	Length
1	40+375	39+980	395	40+100	40+000	100
2	38+050	36+860	1910	38+165	37+050	1115
3	28+000	27+960	40	27+100	27+000	100
4	17+295	16+600	695	5+540	5+340	200
Total =>			3040m	Total =>		1515m

7.2.12 Details of Existing Bus stop

The existing bus-stops have been found at following location with respective village are listed in **Table 7.10**.

Table 7.10: List of Existing Bus Stops

S. No.	Existing Km	Side	Remark
1	48+455	RHS	Kalavad Town
2	44+280	LHS	Nera godown
3	41+440	RHS	For Cross road To Temple
4	40+745	LHS	For Cross road To Nana Badanpar
5	38+720	LHS	Haripar Village
6	31+040	RHS	For Cross road To Dhudasiya
7	28+675	LHS	Motimatli Village
8	22+215	RHS	Matwa Village
9	22+080	LHS	Matwa Village
10	19+860	LHS	For Cross road To Pasaya
11	18+645	RHS	For Cross road To Pasaya
12	17+950	RHS	Sapada Village
13	13+885	RHS	-
14	12+100	LHS	Vijarakhi Village
15	11+210	LHS	For Cross road To Alia bada
16	10+345	RHS	For Cross road To Suvarada

7.2.13 Truck Lay Bye

There is no existing truck lay bye found along the project highway.

7.2.14 Toll Plaza

There is no existing toll plaza all along project highway.

7.3 WIDENING SCHEME

As far as possible the existing road alignment has been followed for the design of horizontal alignment. Existing carriageway is about 6.10m to 7.0m in width is widened as per provisions of 4-lane manual as given in table below i.e. IRC: SP: 84-2019. The typical arrangements of highway elements in rural area, built-up area and in approaches of grade separators are given below in **Figures 7.5 to 7.20**.

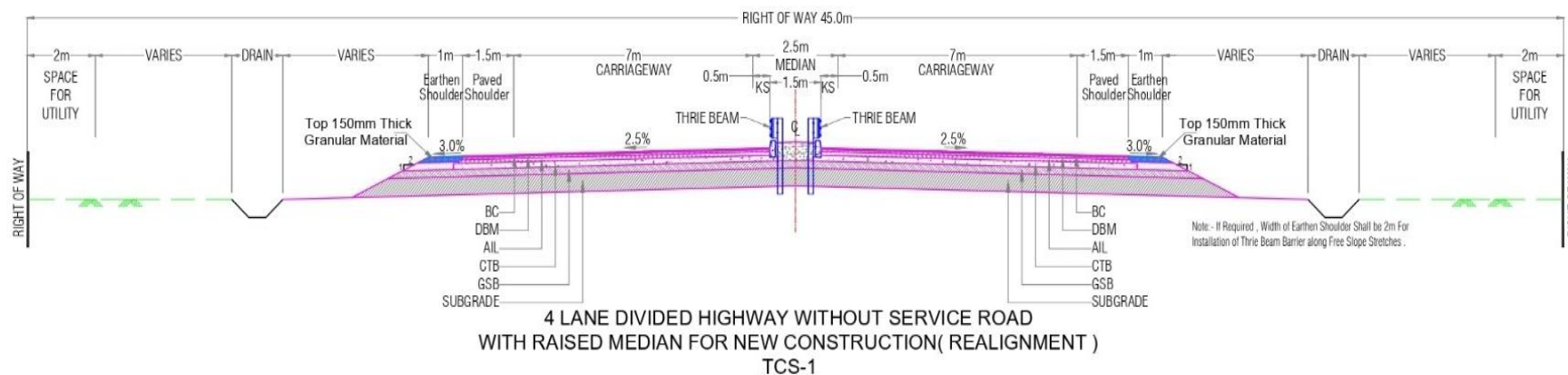


Figure 7.5: TCS-1 for 4 Lane Divided Highway without Service Road with Raised Median for New Construction (Realignment)

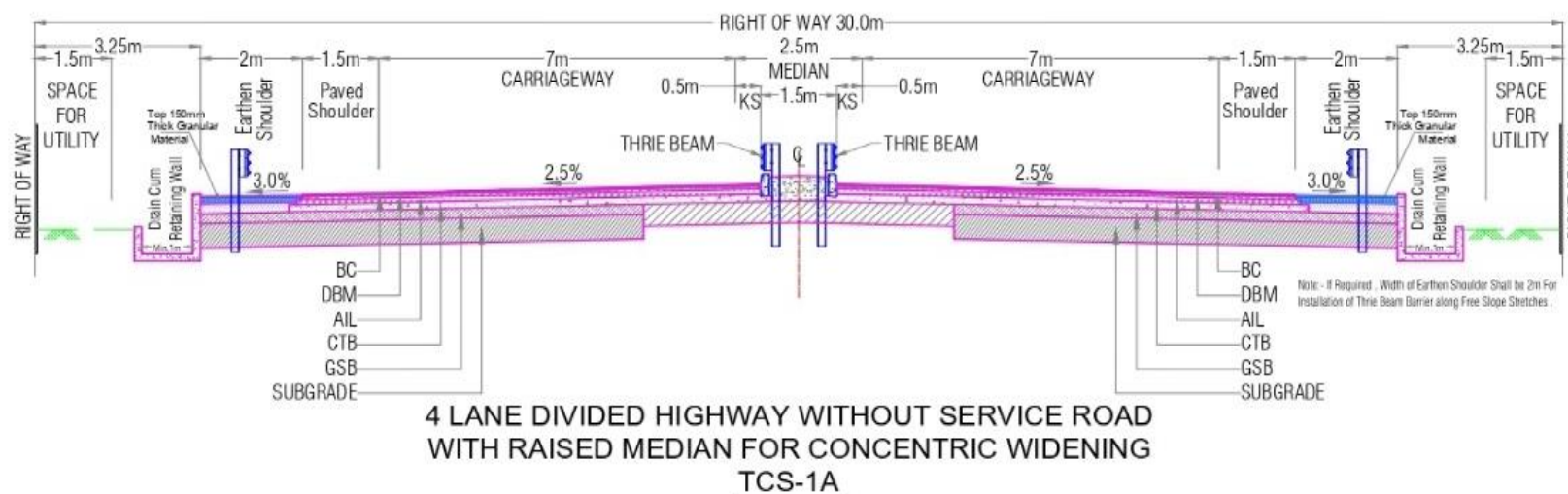


Figure 7.6: TCS-1A for 4 Lane Divided Highway without Service Road with Raised Median for Concentric Widening

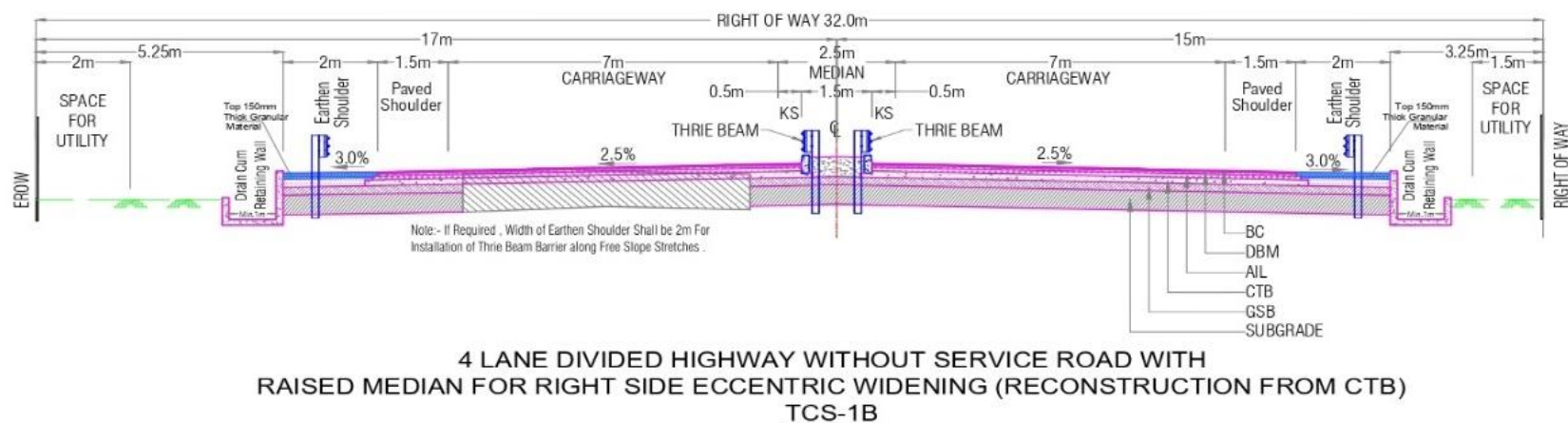


Figure 7.7: TCS-1B for 4 Lane Divided Highway without Service Road with Raised Median for Right side Eccentric Widening (Reconstruction from CTB)

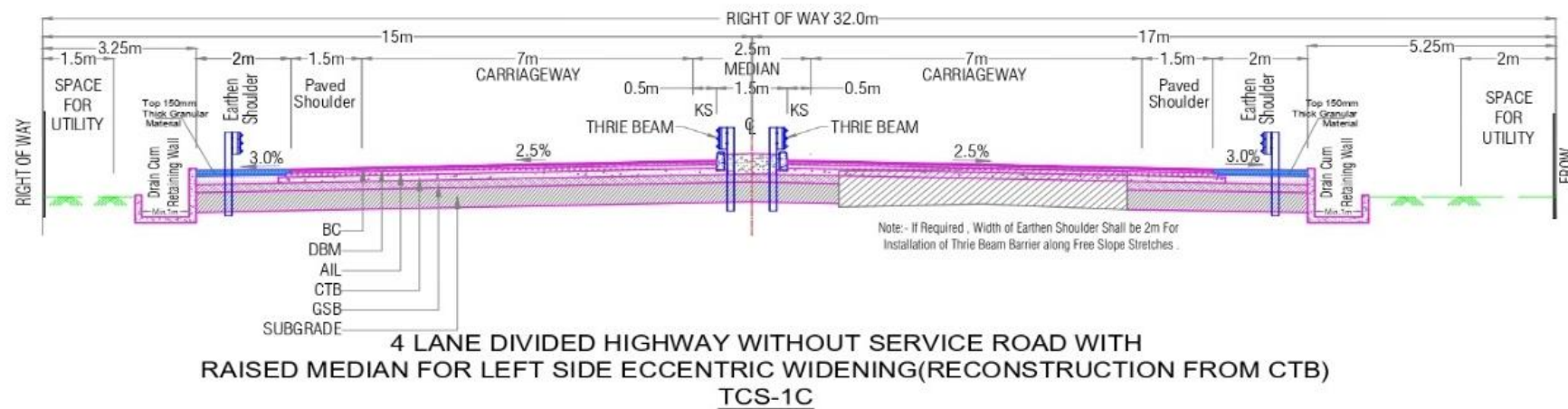


Figure 7.8: TCS-1C for 4 Lane Divided Highway without Service Road with Raised Median for Left side Eccentric Widening (Reconstruction from CTB)

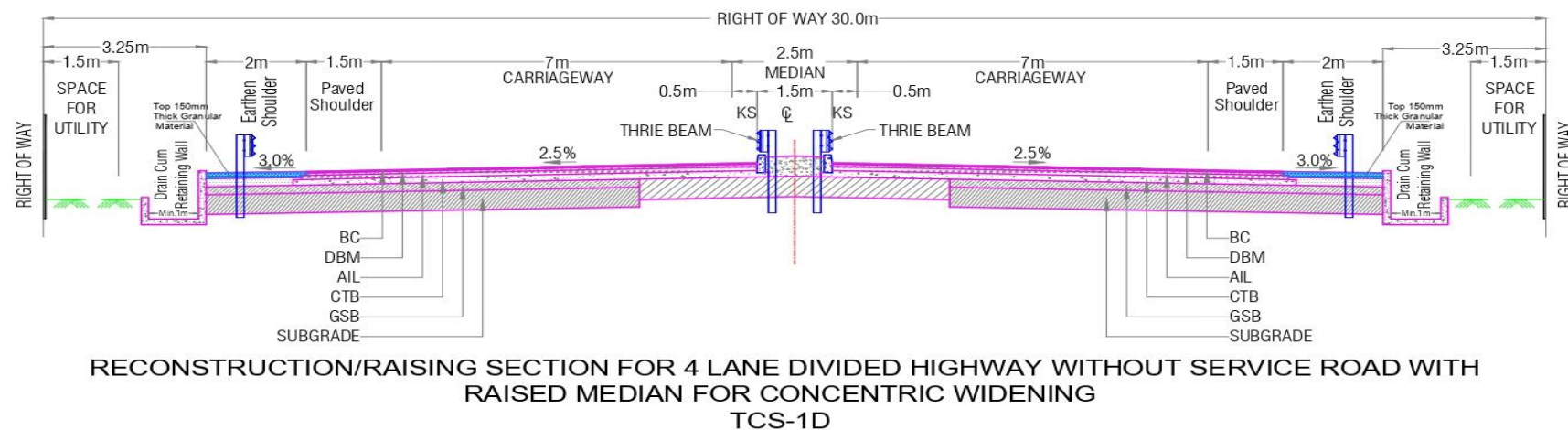


Figure 7.9: TCS-1D for Reconstruction/Raising Section for 4 Lane Divided Highway without Service Road with Raised Median for Concentric Widening

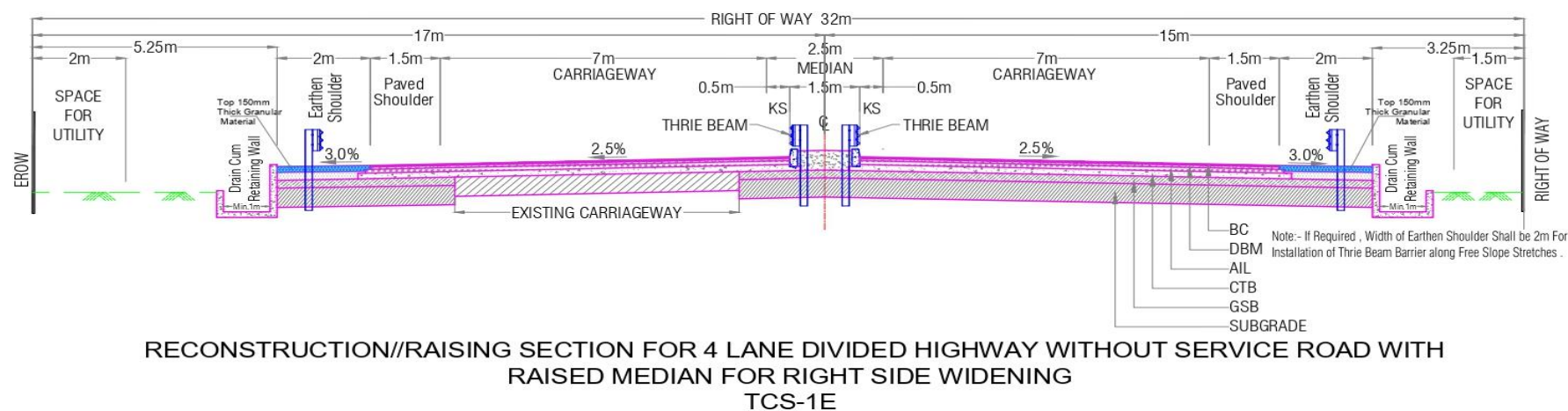


Figure 7.10: TCS-1E for Reconstruction/Raising Section for 4 Lane Divided Highway without Service Road with Raised Median for Right Side Widening

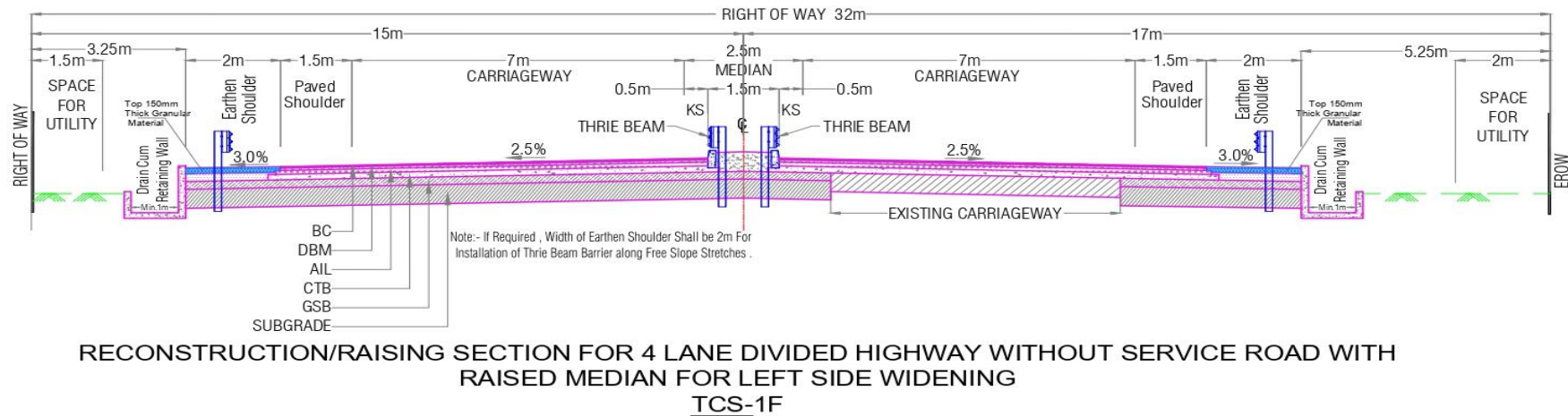


Figure 7.11: TCS-1F for Reconstruction/Raising Section for 4 Lane Divided Highway without Service Road with Raised Median for Left side Widening

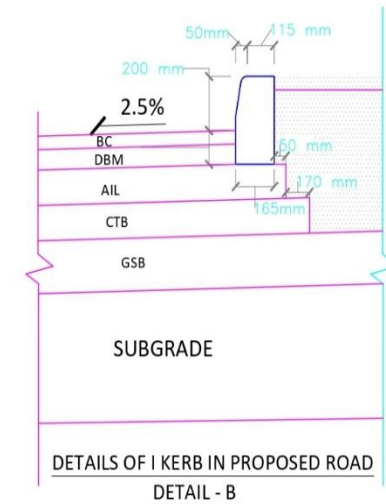
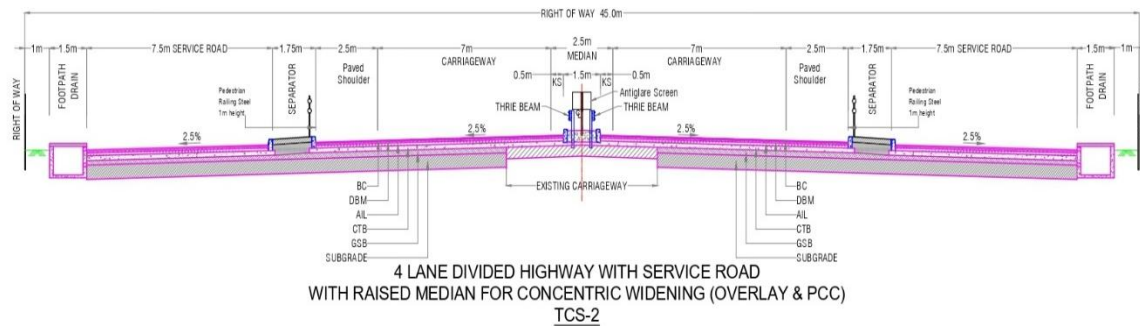


Figure 7.12: TCS-2 for 4 Lane Divided Highway with Service Road with Raised Median for Concentric Widening (Overlay & PCC)

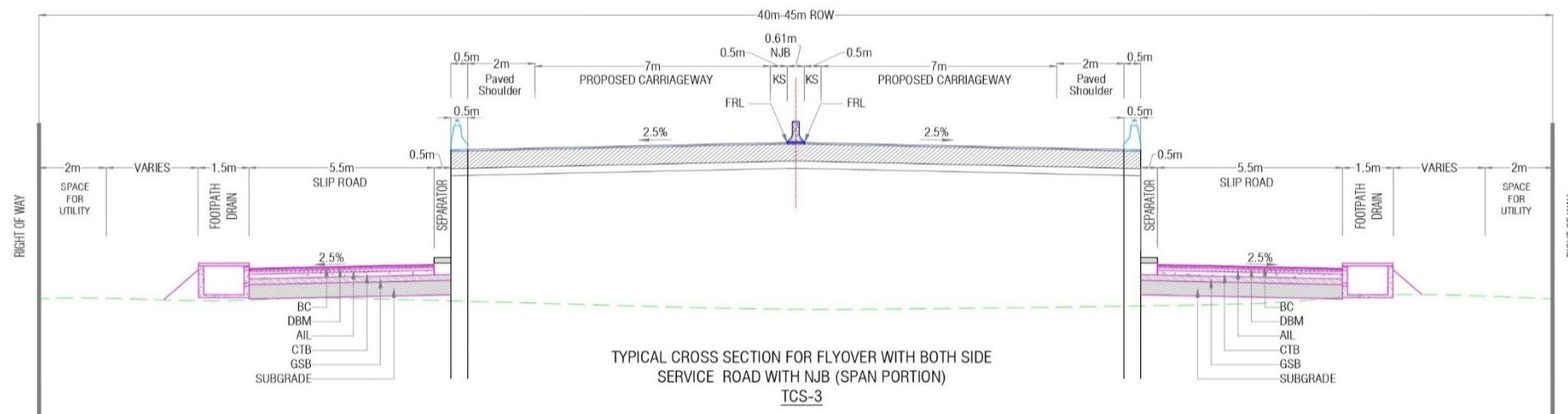


Figure 7.13: TCS-3 Typical Cross Section for Flyover with Both Side Service Road with NJB (Span Portion)

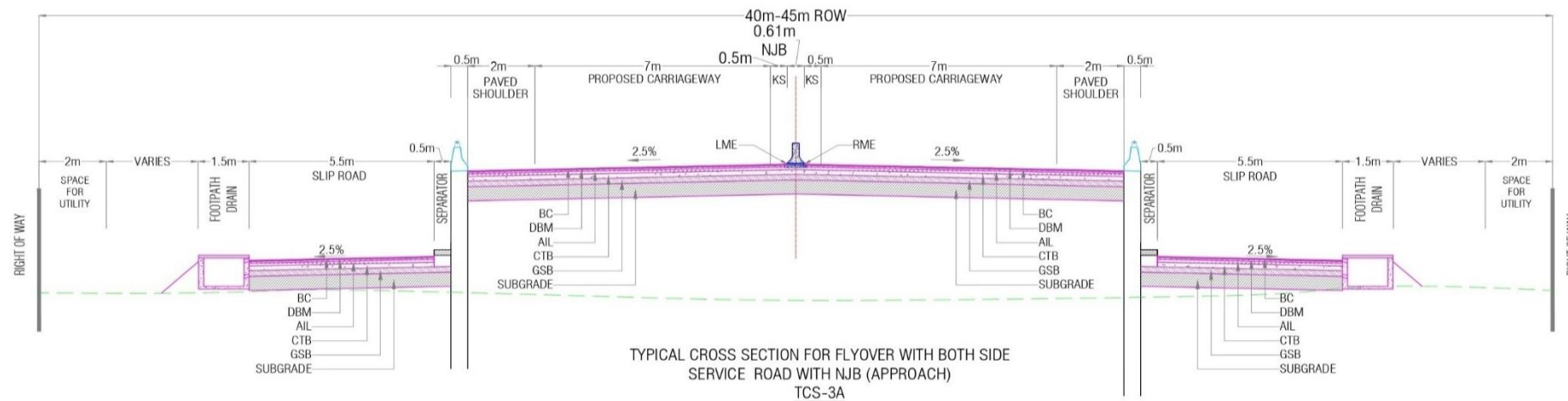


Figure 7.14: TCS-3A Typical Cross Section for Flyover with Both Side Service Road with NJB (Approach)

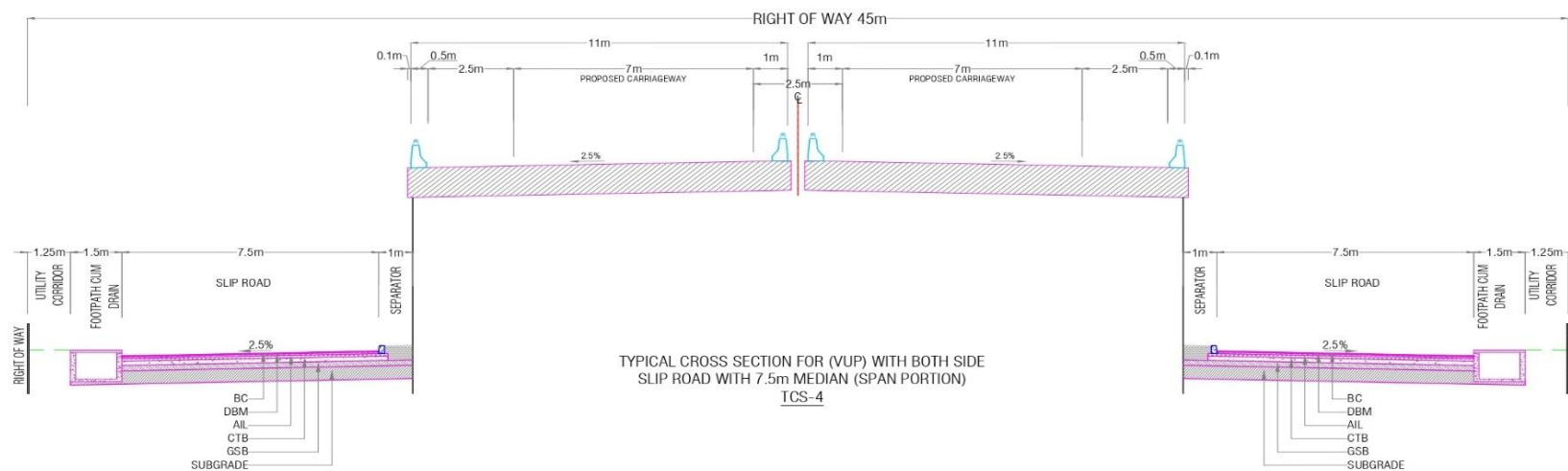


Figure 7.15: TCS-4 Typical Cross Section for VUP with Both Side Slip Road with 7.5m Median (Span Portion)

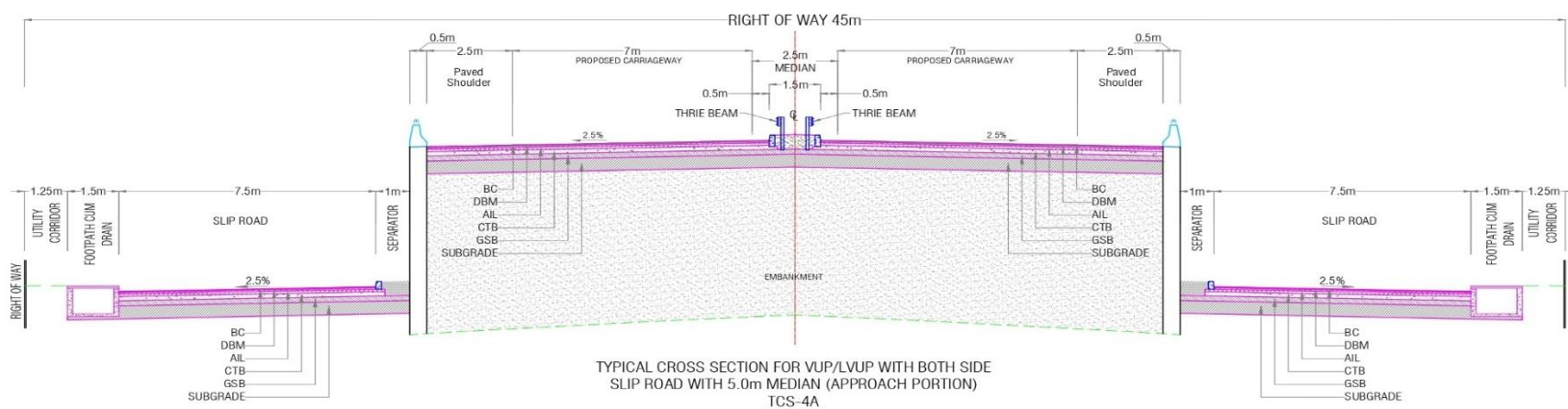


Figure 7.16: TCS-4A Typical Cross Section for VUP/LVUP with Both Side Slip Road with 5.0m Median (Approach Portion)

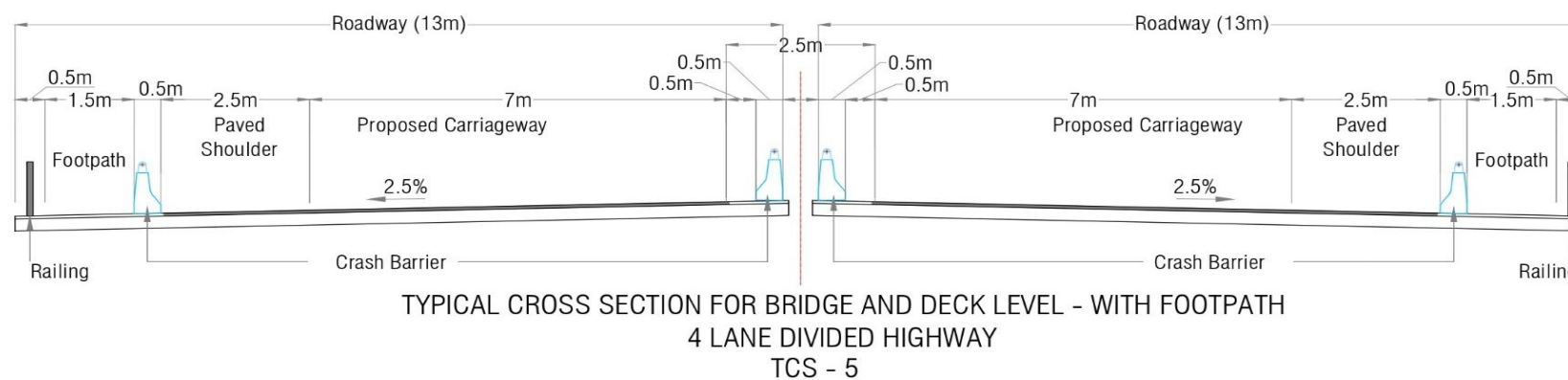


Figure 7.17: TCS-5 Typical Cross Section for Bridge and Deck Level- With Footpath 4 Lane Divided Highway

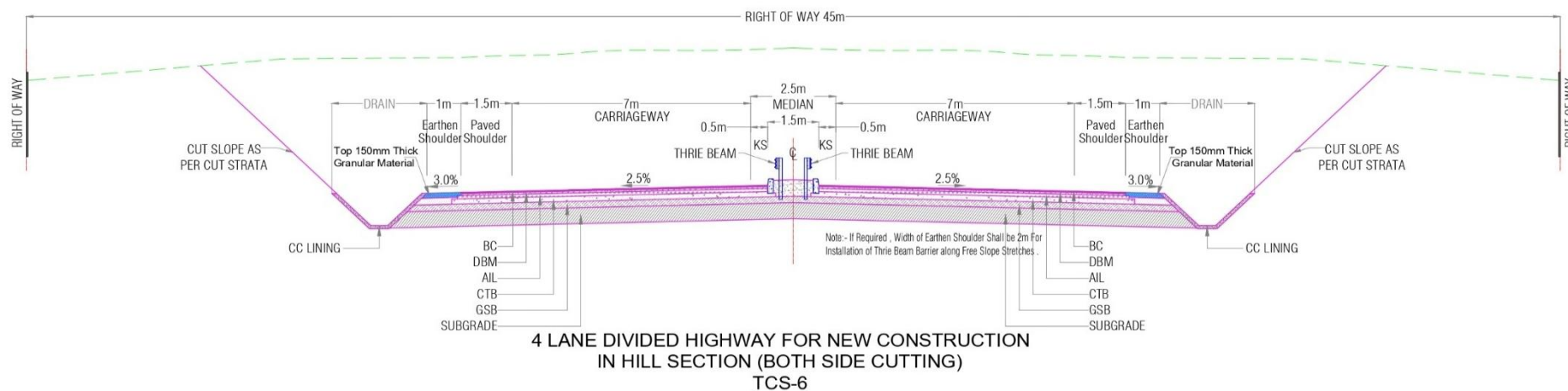


Figure 7.18: TCS-6 4 Lane Divided Highway for New Construction in Hilly Section (Both Side Cutting)

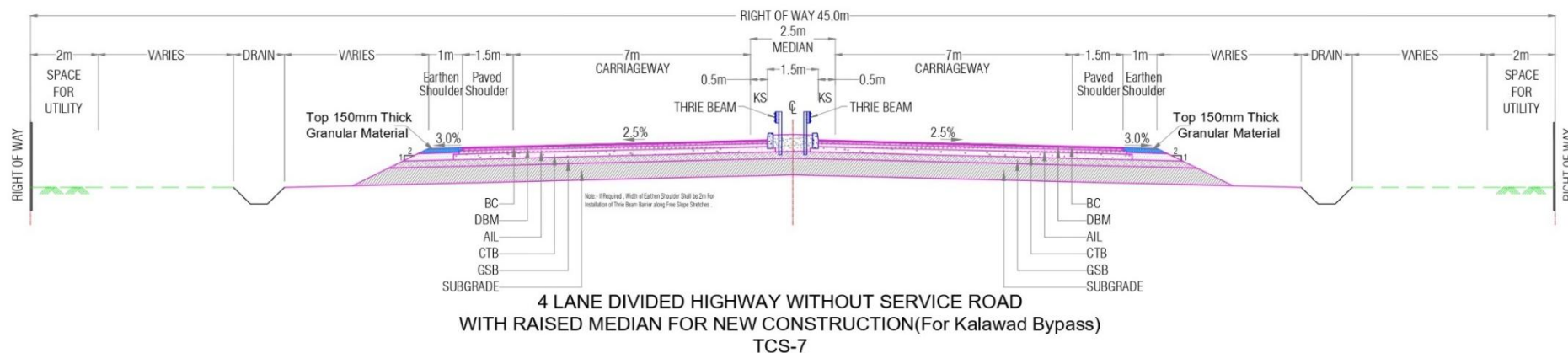


Figure 7.19: TCS-7 for 4 Lane Divided Highway without Service Road with raised Median for New Construction (for Kalavad Bypass)

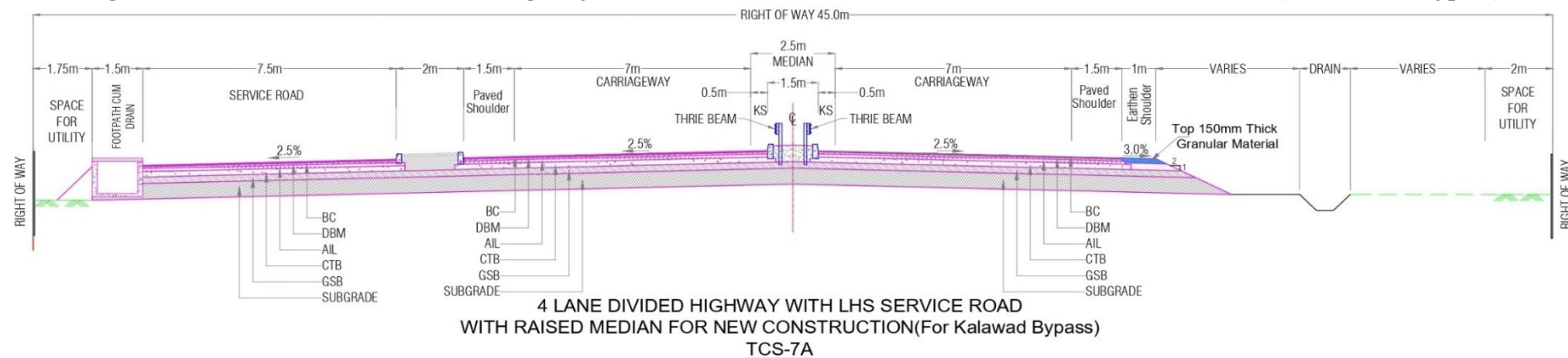


Figure 7.20: TCS-7A for 4 Lane Divided Highway with LHS Service Road with raised Median for New Construction (for Kalavad Bypass)

Note:

- Overlay & PCC with WMM/GSB/BT shall be done with respect to vertical profile keeping minimum VIP distance 150m. Existing BT shall be removed where overlay with WMM/GSB is to be done.
- Where embankment height is more than 6m, kerb with channel shall be provided at the end of paved shoulder as per clause 2.6.2 of IRC:SP:84:2019

TCS Schedule

The indicative TCS schedules are given in table below:

Table 7.11: Typical Cross Section Schedule

S. No.	Design Chainage		Length(m)	TCS Type
	From	To		
1	0	236	236	TCS-7
2	236	516	280	TCS-5
3	516	805	289	TCS-5 to TCS-4A
4	805	1206	401	TCS-4A
5	1206	1226	20	TCS-4
6	1226	1700	474	TCS-4A
7	1700	1970	270	TCS-4A to TCS-7A
8	1970	3845	1875	TCS-7A
9	3845	4130	285	TCS-7A to TCS-4A
10	4130	4588	458	TCS-4A
11	4588	4612	24	TCS-4
12	4612	5200	588	TCS-4A
13	5200	5470	270	TCS-4A to TCS-7A
14	5470	5790	320	TCS-7A
15	5790	6015	225	TCS-7A to TCS-7
16	6015	6073	58	TCS-7
17	6073	6149	76	TCS-5
18	6149	6200	51	TCS-7
19	6200	6410	210	TCS-7 to TCS-7A
20	6410	7165	755	TCS-7A
21	7165	7450	285	TCS-7A to TCS-4A
22	7450	8243	793	TCS-4A
23	8243	8267	24	TCS-4
24	8267	8680	413	TCS-4A
25	8680	8965	285	TCS-4A to TCS-7
26	8965	9340	375	TCS-7
27	9340	9430	90	TCS-7 to TCS-1B
28	9430	11119	1689	TCS-1B
29	11119	11185	66	TCS-1B to TCS-1C

S. No.	Design Chainage		Length(m)	TCS Type
	From	To		
30	11185	11625	440	TCS-1C
31	11625	11683	58	TCS-1C to TCS-1B
32	11683	11983	300	TCS-1B
33	11983	11991	8	TCS-5
34	11991	12140	149	TCS-1B
35	12140	12360	220	TCS-1E
36	12360	12368	8	TCS-5
37	12368	12834	466	TCS-1E
38	12834	12842	8	TCS-5
39	12842	13160	318	TCS-1E
40	13160	13755	595	TCS-1
41	13755	13815	60	TCS-5
42	13815	14357	542	TCS-1
43	14357	14365	8	TCS-5
44	14365	14560	195	TCS-1
45	14560	14790	230	TCS-1E
46	14790	15215	425	TCS-1B
47	15215	15438	223	TCS-1E
48	15438	15484	46	TCS-5
49	15484	15770	286	TCS-1E
50	15770	15949	179	TCS-1B
51	15949	16254	305	TCS-1
52	16254	16454	200	TCS-5
53	16454	17323	869	TCS-1
54	17323	18960	1637	TCS-1B
55	18960	19055	95	TCS-1B to TCS-1
56	19055	19131	76	TCS-1
57	19131	19248	117	TCS-1 to TCS-1C
58	19248	20027	779	TCS-1C
59	20027	20080	53	TCS-1C to TCS-1
60	20080	20216	136	TCS-1
61	20216	20321	105	TCS-1 to TCS-1B

S. No.	Design Chainage		Length(m)	TCS Type
	From	To		
62	20321	20520	199	TCS-1B
63	20520	20660	140	TCS-6
64	20660	22296	1636	TCS-1B
65	22296	22396	100	TCS-1B to TCS-1
66	22396	22519	123	TCS-1
67	22519	22574	55	TCS-1 to TCS-1C
68	22574	22780	206	TCS-1C
69	22780	22822	42	TCS-1C to TCS-1
70	22822	22962	140	TCS-1
71	22962	22992	30	TCS-5
72	22992	23125	133	TCS-1
73	23125	23165	40	TCS-5
74	23165	23395	230	TCS-1E
75	23395	25232	1837	TCS-1B
76	25232	25280	48	TCS-1B to TCS-1
77	25280	25445	165	TCS-1
78	25445	25496	51	TCS-1 to TCS-1B
79	25496	28150	2654	TCS-1B
80	28150	28300	150	TCS-6
81	28300	28807	507	TCS-1B
82	28807	28830	23	TCS-1B to TCS-1
83	28830	28945	115	TCS-1
84	28945	28972	27	TCS-1 to TCS-1B
85	28972	29773	801	TCS-1B
86	29773	29900	127	TCS-1E
87	29900	29930	30	TCS-5
88	29930	30070	140	TCS-1E
89	30070	30330	260	TCS-6
90	30330	30520	190	TCS-1E
91	30520	30590	70	TCS-1E to TCS-1
92	30590	30680	90	TCS-1
93	30680	31030	350	TCS-6

S. No.	Design Chainage		Length(m)	TCS Type
	From	To		
94	31030	31325	295	TCS-1E
95	31325	31349	24	TCS-5
96	31349	31540	191	TCS-1E
97	31540	32880	1340	TCS-1B
98	32880	32999	119	TCS-1A
99	32999	33303	304	TCS-6
100	33303	33560	257	TCS-1E
101	33560	33703	143	TCS-1
102	33703	33767	64	TCS-5
103	33767	34170	403	TCS-1
104	34170	34240	70	TCS-6
105	34240	34303	63	TCS-1B
106	34303	34420	117	TCS-6
107	34420	34928	508	TCS-1B
108	34928	35020	92	TCS-1B to TCS-6
109	35020	35230	210	TCS-6
110	35230	35374	144	TCS-1
111	35374	35455	81	TCS-1 to TCS-1C
112	35455	35873	418	TCS-1C
113	35873	35929	56	TCS-1C to TCS-1
114	35929	35970	41	TCS-1
115	35970	36031	61	TCS-1 to TCS-1C
116	36031	37065	1034	TCS-1C
117	37065	37120	55	TCS-1C to TCS-1
118	37120	37430	310	TCS-1
119	37430	37656	226	TCS-6
120	37656	38739	1083	TCS-1
121	38739	38789	50	TCS-5
122	38789	39090	301	TCS-1
123	39090	39448	358	TCS-6
124	39448	39520	72	TCS-6 to TCS-1C
125	39520	40433	913	TCS-1C

S. No.	Design Chainage		Length(m)	TCS Type
	From	To		
126	40433	40658	225	TCS-1C to TCS-2
127	40658	41367	709	TCS-2
128	41367	41592	225	TCS-2 to TCS-1A
129	41592	41655	63	TCS-1A
130	41655	41810	155	Toll Plaza Tapering
131	41810	41860	50	Toll plaza
132	41860	42015	155	Toll Plaza Tapering
133	42015	42083	68	TCS-1A
134	42083	42178	95	TCS-1A to TCS-1F
135	42178	42206	28	TCS-1F
136	42206	42226	20	TCS-5
137	42226	42468	242	TCS-1F
138	42468	44352	1884	TCS-1C
139	44352	44444	92	TCS-1A
140	44444	44780	336	TCS-1F
141	44780	44801	21	TCS-1D
142	44801	44823	22	TCS-5
143	44823	44942	119	TCS-1D
144	44942	46117	1175	TCS -2
145	46117	46157	40	TCS-2 to TCS-3A
146	46157	46630	473	TCS-3A
147	46630	46700	70	TCS-3
148	46700	47307	607	TCS-3A
149	47307	47572	265	TCS-3A to Existing 2 Lane
Total			47572	

7.4 ROAD EMBANKMENT AND CUT SECTION

7.4.1 Widening and improvement of the existing road

Widening and improvement of the existing road embankment/ cuttings and construction of new road embankment/ cuttings shall conform to the Specifications and Standards given in section 4 of the Manual and the specified cross sectional details. Deficiencies in the plan and profile of the existing road shall be corrected.

7.4.2 Raising of the existing road

The existing road shall be raised in the following sections and as per profile enclosed. Raising of existing road are mainly in the approaches of submersible bridges.

S. No.	Existing Km		Design Chainage		Length (m)	Raising at Existing Bridge Location (m)	Remark
	From	To	From	To			
1	40+213	39+087	12.140	13.160	1020	1.180	Submersible Bridge
2	37+784	37+558	14.560	14.790	230	1.120	Submersible Bridge
3	37+152	36+662	15.215	15.770	555	1.454	Submersible Bridge
4	28+585	28+423	23.164	23.325	161	3.505	Submersible Bridge
5	21+975	21+486	29.773	30.070	297	1.462	Submersible Bridge
6	21+302	21+136	30.330	30.520	190	3.313	Geometric Improvement
7	20+580	20+102	31.030	31.540	510	3.771	Submersible Bridge
8	18+280	17+805	33.303	33.560	257	4.151	Submersible Bridge
9	9+012	8+792	42.178	42.468	290	0.429	Submersible Bridge
10	6+853	6+023	44.444	44.942	498	1.609	Submersible Bridge

7.5 REALIGNMENT/ BYPASSES

There are four major town located at project stretch i.e. Kalavad, Haripar, Khandhera and Vijayraki. Each has been explored in three different options are given in Chapter -7, Volume-I of Final Feasibility Report. By the final feasibility report, bypass has been proposed for Kalvad town and realignment for Haripar, Khandhera and Vijayrakhi town. The detail stretches of Bypass/realignment are as given below:

Table 7.12: Stretches of Bypasses

S. No.	Existing km		Design Chainage		Length (m)	Remarks
	From	To	From	To		
1	50+925	42+930	0.000	9.430	9430	4 Lane Kalavad Bypass

Table 7.13: Stretches of Realignment

S. No.	Existing km		Design Chainage		Length (m)	Remarks
	From	To	From	To		
1	39+197	37+800	13.160	14.560	1400	Haripar Village
2	36+400	34+460	15.930	17.303	1373	Khandera Village
3	14+430	12+235	37.120	39.090	1970	Vijayrakhi Village

7.6 GEOMETRIC IMPROVEMENT AND PROPOSALS

The horizontal curves which are deficient either in radius or in transition lengths and curve length have been improved. The vertical curves which are deficient in curve length and gradients have also been improved. The improvement of geometrics is necessary on National Highways for safety and comfort of road users, even for low traffic volumes.

7.6.1 Alignment Improvement Alternatives

Improvement of existing alignment has been done in following ways which will have significant beneficial impact in terms of

- Minimizing Displacement.
- Reducing resistance to the project.
- Minimize the impact on the existing trees/local environment.
- Maximum benefit in terms of road geometry, pavements, shoulders, embankments etc
- Uninterrupted flow of through traffic along the Project stretch
- Avoid future possibility of installation of speed breakers by the local administration/public
- Avoid adverse impacts of the crowded areas along the project stretch
- Provide scope for wayside amenities

7.6.2 Improvement of Existing Horizontal Curve

The details of Improvement in whole project length are listed below:

Table 7.14: Improvement of Existing Horizontal Curve

S. No.	Existing KM	HIP Design Chainage	Deficiency	Existing Curve Radius	Proposed Radius	Remark
1	49+978	-	Existing Radius is less than absolute minimum required	240	-	Kalawad Bypass has been proposed from the right side of the town with design speed of 100kmph.
2	49+061	-	Existing Radius is less than absolute minimum required	225	-	
3	46+533	-	Existing alignment contains series of sharp curve, reverse curve and Broken back curve	165	-	
4	46+513	-		20	-	
5	46+463	-		50	-	
6	46+363	-		32	-	
7	46+282	-		-	-	
8	44+771	-	Existing Radius is less than Desirable minimum required and Length of curve and transition are insufficient	340	-	
9	44+230		Existing Radius is less than absolute minimum required	220	-	

S. No.	Existing KM	HIP Design Chainage	Deficiency	Existing Curve Radius	Proposed Radius	Remark
10	43+747	-	Length of curve and transition are insufficient	495	-	
11	43+188	-	Length of curve and transition are insufficient	385	-	
12	42+825	-	Length of curve and transition are insufficient	450	-	
13	41+629	10.714	Reverse curve with insufficient length of curve	870 and 6450	2000	The reverse curve eliminated by providing single curve with sufficient length of curve
14	41+153	11.155	Existing Radius is less than Desirable minimum required and Length of curve and transition are insufficient	297	450	Design speed have been Improved to 100 kmph speed with sufficient length of curve and transition
15	40+644	11.687	Existing Radius is less than absolute minimum required	179	400	Improved for Design Speed of 100 kmph
16	39+065	-	Existing alignment having series of sharp reverse curve and Broken back curve in habitation of Haripar village and in approaches of Major Bridge	400	-	Realignment has been proposed at the Haripar Village for minimum design speed of 80 kmph due to constraint of habitation and major bridge.
17	38+965	-		385	-	
18	38+768	-		201	-	
19	38+668	-		161	-	
20	38+518	-		116	-	

S. No.	Existing KM	HIP Design Chainage	Deficiency	Existing Curve Radius	Proposed Radius	Remark
21	38+368	-		220	-	
22	38+068	-		573	-	
23	37+547	14.895	Broken back curve And length of curve is insufficient	264 & 990	500	Broken back curve has been eliminated by providing single curve with proper length of curve and transition
24	36+226	-	Existing alignment contains series of sharp reverse curve, Broken back curve in habitation of Khandhera village and in approaches of Major Bridge	148	-	Realignment has been proposed due to geometric improvement and new construction of major bridge at a design speed of 100 kmph.
25	36+286	-		208	-	
26	36+276	-		355	-	
27	36+176	-		97	-	
28	35+011	-		180	-	
29	34+511	-		78	-	
30	33+840	17.944	Length of curve insufficient as per requirement of deflection angle	855	1600	The curve has been improved with proper length of curve as per requirement of deflection angle
31	32+710	19.109	Existing Radius is less than absolute minimum required	168	400	Improved for Design Speed of 100 kmph
32	31+634	20.168	Existing Radius is less than absolute minimum required	118	400	Improved for Design Speed of 100 kmph

S. No.	Existing KM	HIP Design Chainage	Deficiency	Existing Curve Radius	Proposed Radius	Remark
33	31+185	20.601	Existing Radius is less than absolute minimum required	175	400	Improved for Design Speed of 100 kmph
34	30+424	21.363	Length of curve and transition are insufficient	390	605	The curve has been improved with proper length of curve and transition
35	29+326	22.435	Existing Radius is less than absolute minimum required	117	400	Improved for Design Speed of 100 kmph
36	29+015	-	Existing alignment contains series of sharp curve, reverse curve and Broken back curve	217	400	Improved with Single Curve for design speed of 100 kmph
37	28+872	-		360		
38	28+672	-		190 & 360		
39	28+570	-		360		
40	26+415	25.365	Existing Radius is less than absolute minimum required	111	400	Existing Design speed have been Improved to 100 kmph speed
41	25+265	26.440	Existing Radius is less than Desirable minimum required and inadequate transition length	330	500	Improved for Design Speed of 100 kmph
42	22+743	28.891	Existing Radius is less than absolute minimum required	230	400	Improved for Design Speed of 100 kmph
43	22+485	29.370	Length of curve and transition are insufficient	260	400	The curve has been improved with proper length of curve and transition as required for

S. No.	Existing KM	HIP Design Chainage	Deficiency	Existing Curve Radius	Proposed Radius	Remark
						design speed of 100 kmph.
44	21+375	30.257	Broken back curve and length of transition is insufficient	560 and 320	400	The Broken back curve eliminated by providing single curve with sufficient transition curve length for a Design Speed of 100 kmph
45	20+950	30.678	Broken back curve and Existing Radius is less than absolute minimum required	182 and 155	400	The Broken back curve eliminated by providing single curve with Design Speed of 100 kmph
46	19+980	31.632	Broken Back curve in existing alignment	450 and 6500	1010	Broken Back curve has been improved with single curve radius
47	18+625	32.958	Existing Radius is less than absolute minimum required	225	400	Existing Design speed have been Improved to 100 kmph speed
48	17+925	33.874	Broken back curve and Existing Radius is less than absolute minimum required	110 & 250	500	Improved geometry with single curve for Design Speed of 100 kmph
49	16+370	35.192	Broken back curve and Existing Radius is less than absolute minimum required	183 and 169	400	The Broken back curve eliminated by providing single curve with Design Speed of 100 kmph
50	15+560	35.995	Existing Radius is less than desirable	350	400	Improved for Design Speed of 100 kmph

S. No.	Existing KM	HIP Design Chainage	Deficiency	Existing Curve Radius	Proposed Radius	Remark
			minimum required			
51	14+320	-	Series of sharp curve including broken back curve and reverse curve near Vijarkhi Village and Vijarkhi dam	335	-	Improved by proposing realignment for design speed of 100 kmph
52	14+000	-		95	-	
53	13+895	-		40	-	
54	Re-alignment	-		24	-	
55	13+23	-		59	-	
56	12+932	-		70	-	
57	Re-alignment	-		48	-	
58	Re-alignment	-		64	-	
59	12+210	-		71	-	
60	11+060	40.252	Existing Radius is less than Desirable minimum required and length of curve, transition is insufficient	290	500	Existing Design speed is about 80 kmph have been Improved to 100 kmph speed along with sufficient length of curve required for deflection angle
61	10+745	40.525	Length of curve and transition are insufficient as per existing deflection	310	500	The curve has been improved with proper length of curve and transition as per

S. No.	Existing KM	HIP Design Chainage	Deficiency	Existing Curve Radius	Proposed Radius	Remark
			angle			requirement of deflection angle and design speed of 100kmph
62	10+032	41.257	Length of curve is not sufficient as per existing deflection angle	1050	2000	The curve has been improved with proper length of curve as per requirement of deflection angle
63	6+895	44.400	Existing Radius is less than absolute minimum required	230	450	Improved for Design Speed of 100 kmph
64	6+525	44.782	Existing Radius is less than absolute minimum required	159	400	Improved for Design Speed of 100 kmph
65	5+265	46.029	Small Reverse curve (Undulating Alignment) with insufficient length of curve as per deflection angle	250 and 300	5000	The sufficient length of curve has been provided by eliminating reverse curve by providing single curve
66	5+025	46.264	Broken back curve and Existing Radius is less than Desirable minimum required	270 & 270	500	The Broken back curve eliminated by providing single curve with Design Speed of 100 kmph.

7.7 PROPOSED FLYOVER

The flyover with slip road on both sides has been proposed at the end of project highway at intersection with SH-25 (Jamnagar Bypass). The details of the same are given in table below.

Table 7.15: List of Proposed Flyover

S. No.	Existing Km	Design Chainage	Proposed Span	Type of Cross Road
1	4+700	46.670	2x30m x5.5 clear	NH-947 (SH-25)

7.8 PROPOSED VEHICULAR UNDERPASS

The VUP/LVUP with slip road on both sides has been proposed at the following intersection locations

Table 7.16: List of Proposed Vehicular Underpass (VUP/LVUP)

S. No.	Existing km	Design Chainage	Proposed Structure	Proposed Span (m)	Type of Cross Road	Remarks
1	Bypass	1.216	VUP	2x10.0x5.5 clear	Motabhadukiya road	Kalavad Bypass
2	Bypass	4.600	VUP	2x12x5.5 clear	SH-23	Kalavad Bypass
3	Bypass	8.255	VUP	2x12x5.5 clear	SH-94	Kalavad Bypass

7.9 PROPOSED PEDESTRIAN/ CATTLE UNDERPASS

The CUP has been proposed for the camel/animal cross since the camel occurrences observed at this location.

Table 7.17: List of Proposed Cattle Underpass (CUP)

S. No.	Existing Km	Design Chainage	Proposed Span	Remarks
Nil				

7.10 DRAINAGE ARRANGEMENT ALONG PROJECT HIGHWAY

The RCC covered drain has been proposed in urban/ built-up area and CC Lined drain is also proposed at some stretches. In the rest of the stretches earthen drain has been proposed. The details of drain along the project road are listed in **Table 7.18** below:

Table 7.18: Details of Drain Arrangement along the Project Road

S. No.	Existing Chainage		Design Chainage		Total Length (Km)	Type of Drain	Side	Built-Up Area	Remarks
	From	To	From	To					
1	50+925	Bypass	0+000	0+805	0+805	Earthen drain	Both	-	-
2	Bypass	Bypass	0+805	1+700	0+895	RCC covered drain	Both	-	VUP
3	Bypass	Bypass	1+700	4+130	2+430	RCC covered drain	LHS	-	-
4	Bypass	Bypass	1+700	4+130	2+430	Earthen drain	RHS	-	-
5	Bypass	Bypass	4+130	5+200	1+070	RCC covered drain	Both	-	VUP
6	Bypass	Bypass	5+200	5+790	0+590	RCC covered drain	LHS	-	-
7	Bypass	Bypass	5+200	5+790	0+590	Earthen drain	RHS	-	-
8	Bypass	Bypass	5+790	6+410	0+620	Earthen drain	Both	-	-
9	Bypass	Bypass	6+410	7+450	1+040	RCC covered drain	LHS	-	-
10	Bypass	Bypass	6+410	7+450	1+040	Earthen drain	RHS	-	-
11	Bypass	Bypass	7+450	8+680	1+230	RCC covered drain	Both	-	VUP
12	Bypass	42+930	8+680	9+430	0+750	Earthen drain	Both	-	-
13	42+930	40+377	9+430	11+983	2+553	RCC Drain with Retaining wall	Both		
14	40+377	40+369	11+983	11+991	0+008	Earthen drain	Both		
15	40+369	40+000	11+991	12+360	0+369	RCC Drain with Retaining wall	Both		
16	40+000	39+992	12+360	12+368	0+008	Earthen drain	Both		
17	39+992	39+526	12+368	12+834	0+466	RCC Drain with Retaining wall	Both		
18	39+526	39+518	12+834	12+842	0+008	Earthen drain	Both		

S. No.	Existing Chainage		Design Chainage		Total Length (Km)	Type of Drain	Side	Built-Up Area	Remarks
	From	To	From	To					
19	39+518	39+200	12+842	13+160	0+318	RCC Drain with Retaining wall	Both		
20	39+200	37+785	13+160	14+560	1+400	Earthen drain	Both		
21	37+785	36+907	14+560	15+438	0+878	RCC Drain with Retaining wall	Both		
22	36+907	36+861	15+438	15+484	0+046		Both		
23	36+861	36+396	15+484	15+949	0+465	RCC Drain with Retaining wall	Both		
24	36+396	34+457	15+949	17+323	1+374	Earthen drain	Both		
25	34+457	32+820	17+323	18+960	1+637	RCC Drain with Retaining wall	Both		
26	32+820	32+532	18+960	19+248	0+288	Earthen drain	Both		
27	32+532	31+753	19+248	20+027	0+779	RCC Drain with Retaining wall	Both		
28	31+753	31+459	20+027	20+321	0+294	Earthen drain	Both		
29	31+459	31+375	20+321	20+520	0+199	RCC Drain with Retaining wall	Both		
30	31+375	31+043	20+520	20+660	0+140	CC Lined Drain	Both	-	-
31	31+043	23+483	20+660	22+296	1+636	RCC Drain with Retaining wall	Both	-	-
32	23+483	29+196	22+296	22+574	0+278	Earthen drain	Both		
33	29+196	28+990	22+574	22+780	0+206	RCC Drain with Retaining wall	Both		

S. No.	Existing Chainage		Design Chainage		Total Length (Km)	Type of Drain	Side	Built-Up Area	Remarks
	From	To	From	To					
34	28+990	28+565	22+780	23+165	0+385	Earthen drain	Both		
35	28+565	26+538	23+165	25+232	2+067	RCC Drain with Retaining wall	Both		
36	26+538	26+274	25+232	25+496	0+264	Earthen drain	Both		
37	26+274	23+483	25+496	28+150	2+654	RCC Drain with Retaining wall	Both		
38	23+483	23+186	28+150	28+300	0+150	CC Lined Drain	Both	-	-
39	23+186	21+575	28+300	28+807	0+507	RCC Drain with Retaining wall	Both	-	-
40	21+575	22+663	28+807	28+972	0+165	Earthen drain	Both		
41	22+663	21+755	28+972	29+900	0+928	RCC Drain with Retaining wall	Both		
42	21+755	21+725	29+900	29+930	0+030	Earthen drain	Both		
43	21+725	21+575	29+930	30+070	0+140	RCC Drain with Retaining wall	Both		
44	21+575	21+307	30+070	30+330	0+260	CC Lined Drain	Both	-	-
45	21+307	21+117	30+330	30+520	0+190	RCC Drain with Retaining wall	Both	-	-
46	21+117	20+950	30+520	30+680	0+160	Earthen drain	Both		
47	20+950	20+580	30+680	31+030	0+350	CC Lined Drain	Both	-	-
48	20+580	18+597	31+030	31+325	0+295	RCC Drain with Retaining wall	Both	-	-
49	18+597	18+573	31+325	31+349	0+024	Earthen drain	Both		

S. No.	Existing Chainage		Design Chainage		Total Length (Km)	Type of Drain	Side	Built-Up Area	Remarks
	From	To	From	To					
50			31+349	32+999	1+650	RCC Drain with Retaining wall	Both		
51	18+597	18+282	32+999	33+303	0+304	CC Lined Drain	Both	-	-
52	18+282	17+430	33+303	33+560	0+257	RCC Drain with Retaining wall	Both	-	-
53			33+560	34+170	0+610	Earthen drain	Both		
54	17+430	17+348	34+170	34+240	0+070	CC Lined Drain	Both	-	-
55	17+348	17+285	34+240	34+303	0+063	RCC Drain with Retaining wall	Both	-	-
56	17+285	17+168	34+303	34+420	0+117	CC Lined Drain	Both	-	-
57	17+168	16+575	34+420	34+928	0+508	RCC Drain with Retaining wall	Both	-	-
58			34+928	35+020	0+092	Earthen drain	Both		
59	16+575	16+320	35+020	35+230	0+210	CC Lined Drain	Both	-	-
60	16+320	14+105	35+230	35+455	0+225	Earthen drain	Both	-	-
61	14+105	13+687	35+455	35+873	0+418	RCC Drain with Retaining wall	Both		
62	13+687	13+529	35+873	36+031	0+158		Both		
63	13+529	12+495	36+031	37+065	1+034	RCC Drain with Retaining wall	Both		
	12+495	12+130	37+065	37+430	0+365	Earthen drain	Both		

S. No.	Existing Chainage		Design Chainage		Total Length (Km)	Type of Drain	Side	Built-Up Area	Remarks
	From	To	From	To					
64	12+130	11+904	37+430	37+656	0+226	CC Lined Drain	Both	-	-
65	11+904	10+470	37+656	39+090	1+434	Earthen drain	Both	-	-
66	10+470	10+112	39+090	39+448	0+358	CC Lined Drain	Both	-	-
67	10+112	10+040	39+448	39+520	0+072	Earthen drain	Both	-	-
68	10+040	9+127	39+520	40+433	0+913	RCC Drain with Retaining wall	Both		
69	9+127	8+902	40+433	40+658	0+225	Earthen drain	Both		
70	8+902	8+193	40+658	41+367	0+709	RCC covered drain	Both	Sapada	-
71	8+193	7+968	41+367	41+592	0+225	Earthen drain	Both	-	-
72	7+968	7+905	41+592	41+655	0+063	RCC Drain with Retaining wall	Both		
73	7+905	7+545	41+655	42+015	0+360	Earthen drain	Both		
74	7+545	7+354	42+015	42+206	0+191	RCC Drain with Retaining wall	Both		
75	7+354	7+334	42+206	42+226	0+020	Earthen drain	Both		
76	7+334	4+759	42+226	44+801	2+575	RCC Drain with Retaining wall	Both		
77	4+759	4+737	44+801	44+823	0+022	Earthen drain	Both		
78	4+737	4+618	44+823	44+942	0+119	RCC Drain with Retaining wall	Both		

S. No.	Existing Chainage		Design Chainage		Total Length (Km)	Type of Drain	Side	Built-Up Area	Remarks
	From	To	From	To					
79	4+618	3+984	44+942	47+307	2+365	RCC covered drain	Both	Theba	-
80	3+984	3+720	47+307	47+572	0+265	Earthen drain	Both	-	-
Total Length (km) of RCC Drain					16.598				
(including left & right side)									
Total Length (km) of CC Drain					4.37				
(including left & right side)									
Total Length (km) of Drain with Retaining Wall (including left & right side)					48.156				
Total Length (km) of Earthen Drain									
(including left & right side)					26.02				

7.11 MAJOR AND MINOR JUNCTIONS

Proposal of Junction development has been made for 21 Nos. of intersection along the project highway. Out of which, 17 Nos. are At-grade junction and 4 nos. are grade separated junctions respectively. The lists are given in **Table 7.19**, **Table 7.20** and **Table 7.21**.

Table 7.19: List of Proposed At-grade Major Junctions

S. No.	Existing Km	Design Chainage	Type of Inter-section	Cross Road Type	Cross Road Leading to		Remarks
					LHS	RHS	
1	Bypass	0.115	3-Legged	Existing NH-927D	Kalavad		Start of Kalavad Bypass
2	Bypass	9.190	3-Legged	Existing NH-927D	Kalavad		End of Kalavad Bypass
3	36+345	16.068	3-Legged	Existing NH-927D	Khandhera		At the Start and End of Khandhera Re-alignment
4	34+500	17.273	3-Legged	Existing NH-927D	Khandhera		
5	11+210	40.104	3-Legged	SH		Aliyapada	-

Table 7.20: List of Proposed Grade Separated Junction

S. No.	Existing Km	Design Chainage	Salient Features	Minimum length of viaduct to be provided	Road to be carried over/under the structures
1	Bypass	1.216	VUP	2x10.0x5.5 clear	Mota bhadukiya road
2	Bypass	4.607	VUP	2x12x5.5 clear	SH-23
3	Bypass	8.245	VUP	2x12x5.5 clear	SH-94
4	4+700	46.670	Flyover	2x30m x 5.5 clear	NH-947 (SH-25)

Table 7.21: List of Proposed Minor Junctions

S. No.	Existing Km	Design Chainage	Side	Type of Junction	Type of Surface	Width of Cross Road (m)	Cross Road Leading To
1	Bypass	2+170	RHS	Y	Earthen Road	7	Balambadh
2	Bypass	2+200	LHS	Y	Earthen Road	11	Kalavad

S. No.	Existing Km	Design Chainage	Side	Type of Junction	Type of Surface	Width of Cross Road (m)	Cross Road Leading To
3	Bypass	4+070	BHS	X	Earthen Road	11 LHS & 8 RHS	Kalavad & Dhedh Khijadiya
4	Bypass	5+885	BHS	X	BT	11	Kalavad & Jivapar
5	41+930	10+390	LHS	Y	Earthen Road	8	Vavdi
6	38+710	13+613	RHS	Y	CC	8	Ranuja
7	33+825	18+495	BHS	X	BT	11	Field & Dhudasiya
8	31+030	20+737	RHS	T	BT	8	Varudi Temple
9	29+500	22+260	RHS	T	BT	8	Dhutarpur
10	28+600	23+047	LHS	Y	BT	7	Khankotda
11	22+235	29+390	RHS	Staggered	BT	7	Nani Matli
12	22+165	29+460	LHS		BT	7	Modpar
13	19+850	31+740	RHS	T	BT	7	Pasaya
14	18+000	33+621	RHS	T	BT	11	Beraja
15	17+465	34+145	RHS	Y	BT	9	Sapda
16	12+200	39+087	LHS	Y	BT	7	Miyathara
17	11+980	39+359	RHS	T	CC	7	Vijrakhi
18	10+345	40+940	Both	X	BT	7	Suwarada (LHS) (RHS)
19	8+700	43+195	RHS	T	CC	11	I.O.C. Ltd.
20	6+245	45+040	Both	X	CC & BT	7	Theba (LHS) (RHS)

7.12 PROJECT FACILITIES

7.12.1 Rest Areas

Due to low traffic, there is no rest area is proposed along the project highway.

7.12.2 Truck Lay Bys

As per the site requirement and locations of major town like Kalavad and Jamnagar, 2 no of Truck Lay Bye has been proposed along the project highway. The locations of Truck Lay Bye are as given in table below:

Table 7.22: List of Proposed Truck Lay Bys

S. No.	Existing Km	Design Chainage	Side	Remarks
1	41+844	10.517	Right	After the end of kalavad Bypass
2	7+289	43.982	Left	Before Sapada Town

7.12.3 Bus Bays / Bus Shelter

The Bus Bay and Bus shelter type bus stop has been proposed as per existing bus stop location near to the intersection or built-up area or as per requirement of site. The standard bus bay is proposed and its drawing is separately provided at Volume-IX. There are total of 26 Bus Shelter and Bus Bay proposed on both side of the road. The detailed locations with respective village or cross road are listed in table below.

Table 7.23: List of Proposed Bus Bay/Bus Shelter

S. No.	Description	Ex. Km	Design Ch.	Side	Location
1	Bus Shelter	Bypass	1+148	Left	On the Slip Road of VUP
2	Bus Shelter	Bypass	1+310	Right	On the Slip Road of VUP
3	Bus Shelter	Bypass	4+520	Left	On the Slip road of VUP
4	Bus Shelter	Bypass	4+687	Right	On the Slip road of VUP
5	Bus Shelter	Bypass	8+127	Left	On the Slip road of VUP
6	Bus Shelter	Bypass	8+338	Right	On the Slip road of VUP
7	Bus Bay	41+405	10+940	Left	Cross Road to Nana Badanpar
8	Bus Bay	40+515	11+830	Right	Cross Road to Nana Badanpar
9	Bus Bay	39+285	13+074	Left	Haripar Village
10	Bus Bay	39+168	13+189	Right	Haripar Village
11	Bus Bay	29+101	22+669	Left	Motimatli Village
12	Bus Bay	28+134	23+593	Right	Motimatli Village
13	Bus Bay	22+515	29+135	Left	Matwa Village
14	Bus Bay	22+047	29+607	Right	Matwa Village
15	Bus Bay	20+005	31+605	Left	Cross Road to Pasaya
16	Bus Bay	19+672	31+917	Right	Cross Road to Pasaya

S. No.	Description	Ex. Km	Design Ch.	Side	Location
17	Bus Bay	18+225	33+350	Left	Sapda Village
18	Bus Bay	17+192	34+407	Right	Sapda Village
19	Bus Bay	12+065	39+250	Left	Vijarkhi Village
20	Bus Bay	11+955	39+552	Right	Vijarkhi Village
21	Bus Shelter	10+468	40+822	Left	MotaThavaria Village
22	Bus Shelter	10+285	41+005	Right	MotaThavaria Village
23	Bus Shelter	6+225	45+100	Left	For Cross road to Theba Road
24	Bus Shelter	6+000	45+295	Right	For Cross road to Theba Road
25	Bus Shelter	4+872	46+418	Left	NH-947 (SH-25) /major intersection/ Lumbininagar
26	Bus Shelter	4+453	46+836	Right	NH-947 (SH-25) /major intersection/ Lumbininagar

7.12.4 Toll Plaza

Toll plaza has been proposed at the locations given in table below keeping distance of 60 km between Toll Plaza. All other provision like weigh in motion, static weigh bridge, ETC, Vehicle counting cum classifier unit, lighting etc will be provided as per section 10 of 4-lane Manual.

Table 7.24: List of Proposed Toll Plaza

S. No.	Existing Km	Design Chainage	Remarks
1	9+612	41.833	Minimum 4+1 lane on either side as per the provision of section 10 of 4-lane manual (IRC: SP:84-2019)

7.12.5 Other Misc. Project Facilities

Other Misc. Project Facilities & Safety requirement shall be full filled by providing Metal beam crash barrier, Traffic safety signage's, Road markers, Road boundary stone, Street lighting in built-up areas as per IRC: SP:84-2019.

7.13 TOWN PLAN MAP

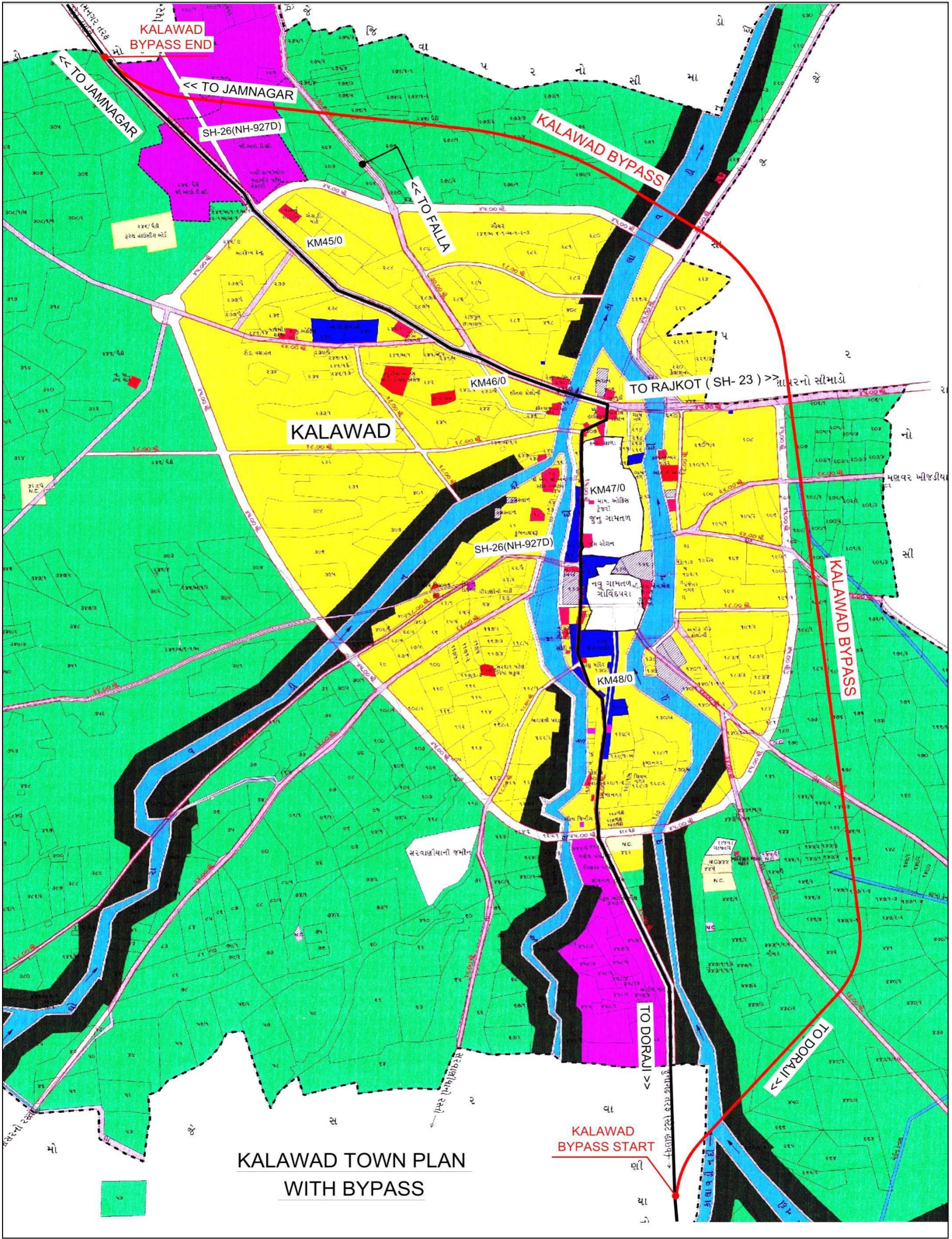


Figure 7.21: Town Plan Map of Kalavad with Bypass

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CHAPTER - 8

PAVEMENT DESIGN

CHAPTER - 8

PAVEMENT DESIGN

8.1 GENERAL

The project envisages widening the existing 2-lane carriageway to 4-lanes for augmenting the capacity of the project road and significantly extending its service life. The strengthening activities will essentially consist of constructing overlays and reconstruction of some severely distressed pavement sections.

For the carriageway in widening, options of both flexible and rigid types of pavements have been studied for arriving at economically most viable designs. The new pavements using above options have been designed for the different project road sections, which are considered homogenous with respect to traffic and CBR of available borrow soil identified for sub grade soil. For the strengthening of the existing pavement, flexible overlays and flexible pavements for stretches requiring widening have been designed. These overlays and pavements have been designed for sections, which are found to be homogenous with respect to both traffic and the condition of the existing pavement. Paved shoulders each of 1.5m width will be provided on both sides of the carriageway. Paved shoulder will have the composition same as that for main carriageway.

8.2 FACTORS AFFECTING PAVEMENT DESIGN

The principal factors that will govern the design of pavements, including overlays for strengthening the existing carriageway, are:

1. Traffic loading that the pavement has to withstand during its design life.
2. Existing pavement condition and strength characteristics of constituent layers.
3. Strength characteristics of the sub grade soil and selected earth borrow areas.
4. Seasonal and climatic variations.
5. Availability of materials for pavement layers.
6. Flood level and ground water table.

8.2.1 Traffic

8.2.1.1 Average Annual Daily Traffic

Based on the traffic survey data, the Average Annual Daily Traffic (AADT) of the both traffic count location has been presented in the **Table 8.1 and Table 8.2.**

Table 8.1: Average Annual Daily Traffic at CVC -1 at km 9+430

Direction	Side	Bus	LCV	Mini LCV	2-Axle Trucks	3-Axle Trucks	Multi Axle Trucks
Kalavad to Jamnagar	LHS	103	177	259	216	73	157
Jamnagar to Kalavad	RHS	95	166	267	201	75	155

Table 8.2: Average Annual Daily Traffic at CVC -2 km 52+200

Direction	Side	Bus	LCV	Mini LCV	2-Axle Trucks	3-Axle Trucks	Multi Axle Trucks
Kalavad to Jamnagar	LHS	74	44	148	93	47	82
Jamnagar to Kalavad	RHS	67	42	125	92	43	93

8.2.1.2 Lane Type

The proposed bypass and realignment shall be 4-lane c/way while the existing highway shall be widened to 4-lane configuration. Locations are shown in **Table 8.3**.

Table 8.3: Proposed Location for 4-laning existing and realignment sections

S. No.	Existing km		Design Chainage		Length (km)	Remarks
	From	To	From	To		
1	3+720	12+235	47.572	39.110	8.462	4-laning of existing c/way
2	12+235	14+430	39.110	37.140	1.970	4-lane Realignment in Vijayrakhi Village
3	14+430	34+460	37.140	17.343	19.797	4-laning of existing c/way
4	34+460	36+400	17.343	15.970	1.373	4-lane Realignment in Khandera Village
5	36+400	38+000	15.970	14.363	1.607	4-laning of existing c/way
6	38+000	39+087	14.363	13.270	1.093	4-lane Realignment in Haripar Village
7	39+087	42+930	13.270	9.430	3.840	4-laning of existing c/way
8	42+930	50+925	9.430	0.000	9.430	4 Lane Kalavad Bypass

8.2.1.3 Design Life

As per the provisions in IRC: SP: 84-2019 manual, the **flexible pavement** for the project road shall be designed for minimum **fifteen (15) years or operation period**, whichever is more and **rigid pavement** for a minimum design period of **thirty (30) years**. Stage construction is not desired.

For this project, Design period of the flexible pavement is considered as 20 years and for rigid pavement it has been considered as 30 years.

8.2.1.4 Design Traffic

On the basis of traffic projections and vehicle damage factors (VDF) for various types of the commercial vehicles, cumulative standard axles (CSA) for the design life have been computed.

The vehicle damage factors (VDF) obtained from the one-day (24 hours) axle load surveys conducted in December, 2024 near Thavariya village at km 9+430 are given in **Table 8.4**.

Table 8.4: Vehicle Damage Factors

Section	Adopted Vehicle Damage Factor				
	Bus	LCV + Mini LCV	2-Axle Trucks	3-Axle Trucks	Multi Axle Trucks
km 3+720 to km 50+925 & Kalavad Bypass	0.80	0.31	7.62	7.56	14.09

The details of Axle Load Survey are given in **Chapter – 4 Traffic Survey and Analysis Report**.

Lane Distribution factor for the 4-Laning of existing carriageway and 4-lane proposed Kalavad Bypass has been presented in **Table 8.5**.

Table 8.5: Lane Distribution Factor as per IRC 37

S. No.	Section	Lane Distribution Factor as per Section 4.5 of IRC 37
1	4-Laning of existing c/way and proposed Realignment	75 % of the number of commercial vehicles in each direction (Dual Two-Lane Carriageway Roads)
2	4-lane proposed Kalavad Bypass	75 % of the number of commercial vehicles in each direction (Dual Two-Lane Carriageway Roads)

Based on the AADT, VDF, LDF, Design Period and Growth Rate (Assumed as 5%), the design traffic (in terms of Million Standard Axle, MSA) has been calculated for 4-lane with paved shoulders. Detailed calculations are given in **Appendix 8.1 – Calculation of Design Traffic** and Summary has been presented in **Table 8.6**.

Table 8.6: Calculated Design Traffic (MSA) Based on December, 2024 Survey

S. No.	Location	Kalavad – Jamnagar Direction (LHS)	Jamnagar – Kalavad Direction (RHS)
1	CVC -1 at km 9+430	44.0	42.7
2	CVC -2 km 52+200	22.2	23.2

On a conservative side, maximum design traffic has been adopted for the pavement design mentioned in the **Table 8.7**.

Table 8.7: Adopted Design Traffic

S. No.	Section	Kalavad-Jamnagar Direction (LHS)	Jamnagar-Kalavad Direction (RHS)
1	4-Laning of existing c/way and proposed Realignment	44	44
2	4-lane proposed Kalavad Bypass	44	44

8.2.2 Condition of Existing Pavement

Detailed pavement investigations carried out along the project road included:

- ❖ Visual condition survey
- ❖ Pavement composition by excavating test pits
- ❖ Roughness survey
- ❖ Benkelman Beam Deflection (BBD) Survey

The details of all the investigations are given in Chapter 5 (Para 5.7) of this report.

8.2.2.1 Visual Inspection

A detailed visual condition survey was carried out along the entire project road to record the pavement distress, condition of shoulders, drainage, embankment height etc. The road condition details are given in **Appendix 8.2 - Pavement Condition Survey**.

8.2.2.2 Pavement Composition

The pavement composition details of the existing pavement were obtained from the examination of test pits excavated at regular intervals along the project road. The details are

given in the report on **Material Investigations**. The existing pavement crust thickness varies for different locations. The crust details are as given below in **Table 8.8**.

Table 8.8: Existing Crust Details

Chainage (km)	Direction	BT Layer (mm)	WBM Layer (mm)	GSB Layer (mm)	Total Crust (mm)
6+800	LHS	195	210	-	405
10+200	RHS	185	200	-	385
10+800	RHS	180	190	-	370
13+500	LHS	155	90	-	245
17+600	RHS	110	90	-	200
20+350	LHS	190	140	-	330
22+500	RHS	160	130	150	440
24+400	LHS	185	160	100	445
28+450	RHS	230	150	-	380
29+400	LHS	240	130	100	470
34+550	RHS	260	140	150	550
35+150	LHS	255	130	140	525
37+500	RHS	210	210	-	420
38+050	LHS	270	210	80	560
38+800	RHS	120	175	390	685
43+600	LHS	148	180	100	428
44+400	LHS	165	150	300	615
49+150	LHS	180	180	100	460
49+650	RHS	200	180	100	480

The total crust thickness varies from 200 mm to 685 mm.

8.2.2.3 Pavement Roughness

The pavement roughness profile in terms of BI values (mm/km), for the package 2 is shown in **Figure 8.1**. The values of LHS and RHS have been shown in this figure.

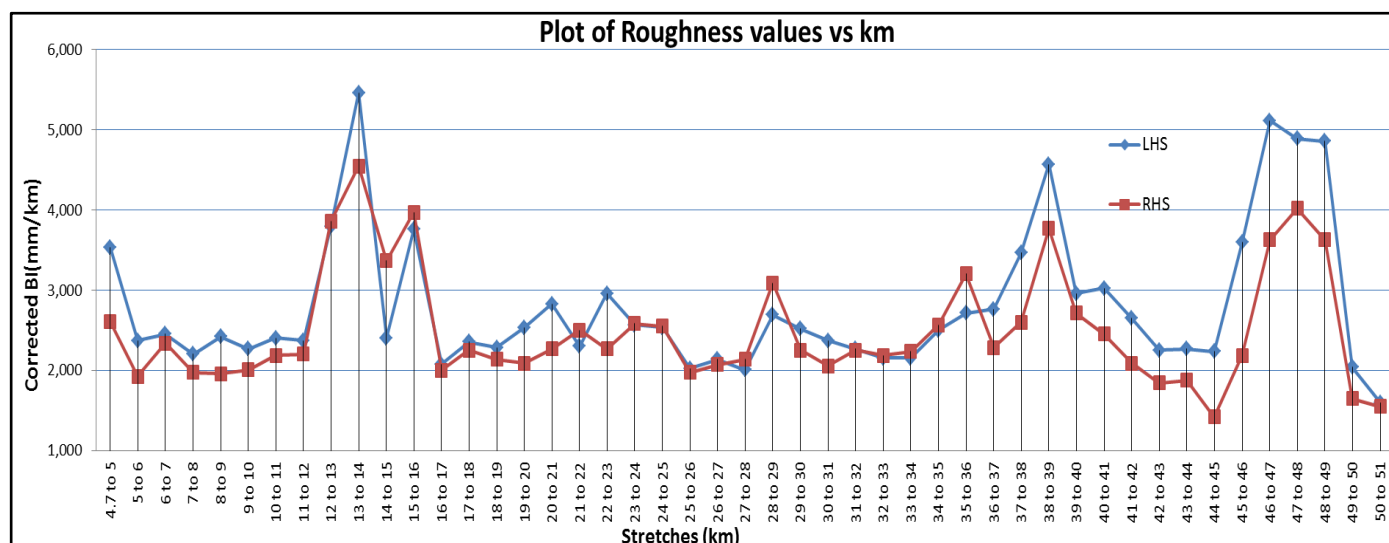


Figure 8.1: Roughness Profile of Project Highway

8.2.2.4 Benkelman Beam Deflection

Benkelman Beam deflection tests on the project road were conducted to evaluate the structural strength of the pavement. The tests were carried out in accordance with the guidelines of IRC: 81-1997. The characteristic deflection values obtained for the stretches identified are as given below:

Table 8.9: Characteristics Deflections for Road Stretch

Section (Km.)	Characteristic Deflection (mm)
Km. 6+000 to Km. 7+000	1.43
Km. 10+000 to Km. 11+000	1.18
Km. 13+000 to Km. 14+000	2.69
Km. 17+000 to Km. 18+000	0.9
Km. 20+000 to Km. 21+000	1.08
Km. 22+000 to Km. 23+000	1.11
Km. 24+000 to Km. 25+000	0.91
Km. 28+000 to Km. 29+000	1.44
Km. 29+000 to Km. 30+000	1.19
Km. 34+000 to Km. 35+000	0.99
Km. 35+000 to Km. 36+000	0.67
Km. 37+000 to Km. 38+000	1.58

Section (Km.)	Characteristic Deflection (mm)
Km. 38+000 to Km. 39+000	1.36
Km. 43+000 to Km. 44+000	1.64
Km. 44+000 to Km. 45+000	1.08
Km. 49+000 to Km. 50+000	1.12

8.2.3 Characteristics of the Existing Subgrade and Borrow Soil

The design of pavement depends upon the strength and other engineering properties of the existing sub-grade soil; the new pavement built on the sub-grade prepared with the selected material obtained from borrows areas found suitable for the purpose.

Detailed investigations of the existing subgrade soil and borrow area material were carried out to determine strength and other engineering properties.

Summary of test results for existing subgrade are given below in **Table 8.10**.

Table 8.10: Existing Sub-grade Soil Details

S. No.	Chainage (in km)	LHS / RHS	Soil Classification	FDD gm/cc	MDD gm/cc	CBR at Field Density (%)	CBR at 97% of MDD (%)
1	6+800	LHS	CL	1.60	2.14	5.96%	17.60%
2	10+200	LHS	ML	1.49	1.87	6.41%	9.20%
3	13+500	LHS	MI	1.40	1.93	2.97%	8.20%
4	17+600	RHS	MI	1.47	1.79	5.26%	6.30%
5	20+350	LHS	MI	1.49	1.88	2.70%	7.10%
6	22+500	RHS	MI	1.65	2.10	5.26%	17.30%
7	24+400	LHS	MI	1.57	1.93	7.20%	9.40%
8	28+450	RHS	CL	1.83	2.09	5.50%	18.80%
9	29+400	LHS	CL	1.67	2.18	10.80%	23.40%
10	33+500	RHS	CI	1.56	1.92	3.57%	4.00%
11	34+550	RHS	MI	1.38	1.75	3.48%	4.60%
12	35+150	LHS	MI	1.36	1.92	2.59%	6.00%
13	38+800	RHS	CL	1.52	2.12	4.01%	16.50%
14	43+600	RHS	CI	1.77	2.06	12.09%	11.20%
15	44+400	LHS	SM	1.63	2.05	6.74%	19.40%
16	49+650	RHS	CI	1.69	1.97	10.80%	11.00%

During the field investigations, 13 new borrow areas were identified and evaluated in the laboratory. Out of these, the details of borrow areas with CBR ranging from 14% to 18% are given below in **Table 8.11**.

Table 8.11: Borrow Area Evaluation Data

S. No.	Location (in km)	Lead in km	Area	LHS/ RHS	Soil Classification	CBR Value (At 97% MDD)
1	9+200	1.0 km	32000 m ²	RHS	SP-SM	18%
2	21+800	1.0 km	35000 m ²	LHS	MI	15%
3	29+200	0.5 km	19500 m ²	LHS	MI	14%
4	39+700	On Road	16000 m ²	LHS	MI	15%
5	78+200	0.2 km	24000 m ²	RHS	MI	16%
6	80+200	2.0 km	19500 m ²	LHS	MI	18%

8.3 PAVEMENT DESIGN ALTERNATIVES

The pavement design has been carried out for both flexible and rigid pavements. The flexible pavement has been designed as per IRC: 37 guidelines, while rigid pavement has been designed as per IRC: 58-2015. In IRC: 37, six design combinations are discussed, amongst those two design combinations are considered (i) flexible pavement with granular base & subbase (ii) flexible pavement with cement treated base & granular subbase. The existing carriageway is 7 m wide having granular base & sub-base and concentric widening has been proposed along the entire project length, except few stretches wherein due to curve improvements new pavement shall be provided. In view of the design strategy & considered design options, new design can be carried out in three ways.

- **Option I** - The existing pavement is retained and overlay & widening is carried out then flexible pavement with granular base & subbase shall be provided in the widening portion.
- **Option II** - The existing pavement is dismantled and flexible pavement with cement treated base & granular subbase shall be provided on the entire carriageway width.

The design of new flexible and strengthening of existing pavement is discussed in detail in the subsequent sections.

8.4 NEW FLEXIBLE PAVEMENT DESIGN

The existing road shall be widened to four lanes with paved shoulders standards by providing crust as per the new design requirement.

New four-lane pavement shall be constructed for proposed realignments. New four-lane pavement with paved shoulders shall be provided for proposed Kalavad bypass.

8.4.1 Design Method

The flexible pavement has been designed as per IRC: 37 design guidelines.

8.4.2 Design Inputs

8.4.2.1 Design Traffic

The design traffic in MSA for widening/realignment/reconstruction and Kalavad bypass sections is given in **Table 8.12** below.

Table 8.12: Adopted MSA

S. No.	Section (Km)	Kalavad-Jamnagar Direction (LHS)	Jamnagar-Kalavad Direction (RHS)
1	4-Laning of existing c/way and proposed Realignment	44	
2	4-lane proposed Kalavad Bypass	44	

8.4.2.2 Design CBR

As per the guidelines of IRC: 37, where there is significant difference between the CBRs of the select subgrade and embankment soils, the design should be based on effective CBR. The CBR of existing subgrade along the project road is varying from 3% to 14%, with an average 5% to 6% CBR, while, as per the availability of borrow soil; material of minimum CBR 14% to 18% is available along the project road. Since, the difference between the two i.e. borrows area soil and existing subgrade & embankment soil is significant, effective CBR shall be considered as design CBR. Therefore, keeping in view the availability of soil, the design has been proposed for 8% CBR.

8.4.2.3 Design Approach

The flexible pavement design for the project road has been done considering Cl 10.1 – Granular Base and Granular Subbase & Cl 10.6 – Granular Base and Cemented Subbase design option of IRC: 37, duly taking into account the long-term performance and constructability aspects at site.

The design of new pavement has been carried out as per the mechanistic design approach of IRC: 37 using IITPAVE software. In the design process, the tensile strain (ϵ_t) is calculated at the bottom of bituminous layer and vertical compressive strain (ϵ_c) at the top of subgrade. The calculated strain values should always be less than the allowable strain values. The allowable strain has been calculated from the equations given below:

Equation for Fatigue criteria

$$N_f = 0.5161 \times C \times 10^{-04} [1/\varepsilon_t]^{3.89} \times [1/M_{Rm}]^{0.854} \text{ (for 90\% Reliability)}$$

$$N_f = 1.6064 \times C \times 10^{-04} [1/\varepsilon_t]^{3.89} \times [1/M_{Rm}]^{0.854} \text{ (for 80\% Reliability)}$$

Where,

N_f = MSA,

$C = 10^M$

$M = 4.84 (V_a / (V_a + V_b) - 0.69)$

ε_t = Tensile strain at bottom of the DBM layer

M_R = Elastic Modulus of VG 40 bitumen

$V_a = 3.5\%$ and $V_b = 11.5\%$ is considered for DBM layer.

Equation for Rutting criteria

$$N_R = 1.4100 \times 10^{-08} [1/\varepsilon_v]^{4.5337} \text{ (for 90\% Reliability)}$$

$$N_R = 4.1656 \times 10^{-08} [1/\varepsilon_v]^{4.5337} \text{ (for 80\% Reliability)}$$

Where,

N_R = number of cumulative standard axles

ε_v = Vertical strain at top of the subgrade

Equation for Fatigue criteria of CTB Layer

$$N = RF \left[\frac{\left(\frac{113000}{E^{0.804}} + 191 \right)}{\varepsilon_t} \right]^{12}$$

Where,

N = number of cumulative standard axles

RF = Reliability factor for cementitious materials for failure against fatigue (for 90% Reliability it is 1 and for 80% Reliability it is 2)

E = Elastic modulus of CTB layer (in MPa)

ε_t = Tensile strain at bottom of CTB layer

The input parameters adopted for the design are as follows:

Table 8.13: IITPAVE Design Inputs

Parameters	Details	Remarks
Wheel Load	20000 N	80 kN (Standard Axle Load)
Tyre Pressure	0.56 MPa 0.80 MPa	for bituminous layer and subgrade for cement treated base layer
Poison Ratio	0.35	Bituminous Layer, unbound granular base, sub base layer
	0.35	Subgrade Layer
	0.25	Cemented Layer
M _R of Bituminous Layer	3000 MPa	VG 40 at 35 ⁰ C (Table 7.1 of IRC 37)
E _{cemented base of cemented base}	5000 MPa	As per IRC 37 2018
E _{subgrade}	66.602 MPa (8% CBR)	17.6 x CBR ^{0.64}
E _{sub-base & base}	Based on Eq 7.1 of IRC 37 2018	0.2 x E _{subgrade} x h ^{0.45}
Reliability	90%	For Main Carriageway, Slip / Service Road

Table 8.14: Conventional Flexible Pavement Design in Widening and New Construction

Design Traffic (MSA)	Location	BC (mm)	DBM (mm)	WMM (mm)	GSB (mm)	Total (mm)
44	4-Laning of existing c/way and proposed Realignment & 4 – Lane Kalavad Bypass	40	110	250	200	600

Table 8.15: Flexible Pavement with Cement treated Base and Granular Sub-Base

Design Traffic (MSA)	Location	BC (mm)	DBM (mm)	AIL (mm)	CTB (mm)	GSB (mm)	Total* (mm)
44	4-Laning of existing c/way and proposed Realignment & 4 – Lane Kalavad Bypass	40	60	100	165	200	565

* Mention pavement layers thicknesses are based on only strain analysis. This pavement layers thickness may increase after cumulative fatigue damage analysis.

8.5 STRENGTHENING OF EXISTING PAVEMENT

8.5.1 Approach for overlay design

In order to rehabilitate and strengthen the existing pavement, bituminous overlay has been suggested keeping in view the type of crust already provided. The overlay is designed in accordance with IRC: 81-1997 for a design period of 15 years post construction. Detailed pavement condition survey is conducted by both visual inspection and instrumental measurements of the condition indicators like deflection. Benkelman Beam deflection test and Test Pit Evaluation were done for evaluation of the existing pavement.

The homogeneous sections are same as adopted for new pavement design. BBD values adopted for overlay design are after removing outliers. Initial strengthening of pavement has been done according to IRC-81-1997, IRC: SP: 84-2019.

8.5.2 Overlay Design

The overlay has been worked out based on the characteristic deflection and traffic conditions. The overlay details for the entire project length are given below in **Table 8.16**. The overlay thickness worked out in terms of BM thickness from IRC: 81, has been converted into VG 40 BC and DBM requirements.

Table 8.16: Suggested Overlay Design

Existing km		Length (km)	Deflection (mm)	LHS				RHS			
From	To			MSA	BC (mm)	DBM (mm)	Total Thickness (mm)	MSA	BC (mm)	DBM (mm)	Total Thickness (mm)
3+720	9	5.28	1.43	44	40	60	100	44	40	60	100
9	12	3	1.18	44	40	50	90	44	40	50	90
12	13	1	2.69	44	40	105	145	44	40	105	145
13	14	1	2.69	44	40	105	145	44	40	105	145
14	16	2	2.69	44	40	105	145	44	40	105	145
16	27	11	1.11	44	40	50	90	44	40	50	90
27	33	6	1.44	44	40	60	100	44	40	60	100
33	36	3	0.99	44	40	50	90	44	40	50	90
36	39	3	1.58	44	40	70	110	44	40	70	110
39	41	2	1.36	44	40	60	100	44	40	60	100
41	50+925	9.925	1.64	44	40	75	115	44	40	75	115

Before implementing the strengthening treatment, the existing pavement surface profile shall be checked and if found deficient, shall be corrected by providing a suitable profile corrective course or by milling and recycling. The profile corrective course shall meet the following requirements:

- (i) The profile corrective course shall not form part of the overlay thickness.
- (ii) Where the maximum thickness of profile corrective course is not more than 40 mm, it shall be constructed as an integral part of the overlay course. In other cases, the profile corrective course shall be constructed as a separate layer.
- (iii) Where it is to be laid as integral part of the overlay/ strengthening course, the profile corrective course material shall be of the same specifications as that of the overlay/ strengthening course.

8.6 PAVEMENT DESIGN FOR RECONSTRUCTION STRETCHES

Detailed study of the existing pavement condition has been done by conducting all the necessary surveys like pavement condition survey, roughness survey, Benkelman Beam Deflection (BBD) Testing, Test Pit Investigation, Test results of Existing Sub-grade etc. Based on these surveys the problematic stretches have been identified. Problematic stretches are those stretches where existing pavement condition is highly deteriorated and/or the analysis of test results depicts possible weakness in the pavement structure. All parameters are analysed for problematic stretches to decide rehabilitation alternative.

The stretches identified are found to be in poor condition, having low compaction of existing sub-grade, high roughness, low CBR at FDD and clayey soil in the sub-grade. Overlay on these stretches will result in reflection cracking in due course of time and will increase maintenance cost. Thus, it is proposed to improve the stretches from sub-grade level by further compaction and building as new pavement.

The stretches identified for reconstruction are tabulated below:

Table 8.17: Proposed Reconstruction Stretches with Pavement Composition

Existing Km		Length (km)	CBR	Reasons	New pavement Layer Thickness to be provided after subgrade re-compaction		
From	To				Side	BC+ DBM	WMM+GSB
38	39	1.000	8%	Low compaction density of existing sub-grade, high roughness & clayey soil	LHS	40+110	250+200
					RHS	40+110	250+200

8.7 DESIGN OF RIGID PAVEMENT FOR TOLL PLAZA

IRC: 58-2015 “Guidelines for the Design of Plain Jointed Rigid Pavements for Highways” have been followed for the design of new rigid pavement.

The rigid pavement design has been considered for the toll plaza locations. The rigid pavement has been designed for a life of thirty (30) years. To withstand the cumulative effect of the axle load repetitions of different commercial vehicles applied over this period. 25% of the cumulative repetitions of commercial vehicles for 30 years are taken as the design traffic for computing the expected axle load repetitions for design.

The cumulative number of commercial axles is considered for year 2049, while axle load spectrum has been obtained for the direction carrying maximum loads. The maximum commercial traffic is observed at km 9+430 with heavy loads in Kalavad to Jamnagar direction.

8.7.1 Axle Load Spectrum

The axle load survey was carried out near Thavariya village at km 9+430 in December 2024, the maximum loading data (LHS direction) has been considered for obtaining the axle load spectrum. The axle load spectrum considered for design is as given in **Table 8.18**.

Table 8.18: Axle Load Spectrum (Kalavad to Jamnagar)

Rear Single Axle			Rear Tandem Axle			Rear Tridem Axle		
Load Group (kN)	Mid-Point of Load Group (kN)	Frequency (%)	Load Group (kN)	Mid-Point of Load Group (kN)	Frequency (%)	Load Group (kN)	Mid-Point of Load Group (kN)	Frequency (%)
205-215	210	0.00	420-440	430	0.00	590-620	605	0.00
195-205	200	0.00	400-420	410	0.00	560-590	575	0.00
185-195	190	6.56	380 - 400	390	1.03	530-560	545	0.00
175-185	180	7.38	360 - 380	370	0.00	500-530	515	0.00
165-175	170	4.92	340 - 360	350	0.00	470-500	485	0.00
155-165	160	4.92	320 - 340	330	10.31	440-470	455	0.00
145-155	150	3.28	300 - 320	310	3.09	410-440	425	7.69
135-145	140	0.00	280 - 300	290	2.06	380-410	395	7.69
125-135	130	4.10	260 - 280	270	6.19	350-380	365	0.00
115-125	120	10.66	240 - 260	250	2.06	320-350	335	15.38

Rear Single Axle			Rear Tandem Axle			Rear Tridem Axle		
Load Group (kN)	Mid-Point of Load Group (kN)	Frequency (%)	Load Group (kN)	Mid-Point of Load Group (kN)	Frequency (%)	Load Group (kN)	Mid-Point of Load Group (kN)	Frequency (%)
105-115	110	13.11	220 - 240	230	3.09	290-320	305	0.00
95-105	100	5.74	200 - 220	210	2.06	260-290	275	7.69
85-95	90	2.46	180 - 200	190	3.09	230-260	245	0.00
< 85	80	36.89	< 180	170	67.01	< 230	215	61.54
Total		100.00			100.00			100.00

8.7.2 Design Philosophy Adopted

Rigid Pavement design is worked out as per IRC: 58-2015. The input parameters used for the design of rigid pavement are given in **Table 8.19**.

Table 8.19: Input Parameters

Design Parameters	Values Adopted
Inputs for Design of Rigid Pavement	
Subgrade CBR, %	8%
Transverse joint spacing (m)	4.5
Lane width (m)	4.5
CVPD in the year of completion of construction	1034
Cumulative No of Commercial Axles during design period maximum traffic has been considered	2,50,80,748
Modulus of subgrade reaction of subgrade, MPa/m	50.33
Thickness of Dry Lean Concrete, mm	150
Effective modulus of subgrade reaction over 150 mm DLC, MPa/m	284.66
Unit weight of Concrete, kN/m ³	24
28-day Flexural strength of cement concrete, MPa	4.5
Trial PQC Thickness, mm	260
Max. day-time Temperature Differential in slab, °C (for bottom-up cracking) – Depends on Slab Thickness	14.6

Design Parameters	Values Adopted
Night-time Temperature Differential in slab, $^{\circ}\text{C}$ (for top-down cracking)	12.3
Elastic Modulus of Concrete, E_c (MPa)	30,000
Poisson's Ratio of Concrete, (μ)	0.15
Inputs for Design of Tie Bars	
Coefficient of friction, f	1.5
Density of Concrete, W (kN/cu.m)	24
Allowable tensile stress in bars, f_s (MPa) – Deformed Bars	200
Allowable bond stress for tie bars, f_b (MPa) – Deformed Bars	2.46

8.7.3 Rigid Pavement Composition

The recommended design of rigid pavement for the input parameters as above is given in **Table 8.20**.

Table 8.20: Rigid Pavement Design

Design Parameters	Calculated Values
PQC (mm) M 40 Grade Concrete	280*
DLC (mm) M 10 Grade Concrete	150
GSB (mm)	150
Concrete Grade (kg/cm^2)	240
Slab Length (m)	4.5
Slab Width (m)	3.5
Joint Width (mm)	20
Dowel Bar Dia (mm)	36
Spacing of Dowel Bar (mm)	300
Length of Dowel Bar (mm)	450
Tie Bar Dia (mm) – Deformed Bars	12
Spacing of Tie Bar (mm)	500
Length of Tie Bar (mm)	640

* Thickness is included of two retexturing and grinding to rectify faulting during service life

The above-mentioned design shall be applicable for the proposed toll plaza(s). The detailed analysis sheet is given in **Appendix 8.3 - Rigid Pavement Design**.

8.8 DESIGN OF PAVED AND EARTHEN SHOULDERS

8.8.1 Paved Shoulders

The paved shoulders shall be constructed in layers, each matching the thickness of the adjoining pavement layer in accordance with Clause 407 of MoRTH Specifications. The crust thickness of paved shoulders shall be same as that of the main carriageway.

8.8.2 Earthen Shoulders

The top 150 mm of earthen shoulder shall consist of well graded natural Moorum, gravel, crushed stone or combination conforming to Clause 401 of MoRTH Specifications having soaked CBR value not less than 30%. The granular layer shall be compacted to at least 98% of the maximum dry density. The remaining portion shall conform to Section 300 of MoRTH Specifications.

8.9 SLIP AND SERVICE ROAD DESIGN

Slip and Service Road is designed for 20 MSA, 8% CBR and 90% reliability.

Table 8.21: Pavement Layer Thickness for Slip and Service Road

BC (mm)	DBM (mm)	AIL (mm)	CTB (mm)	GSB (mm)	Total (mm)
30	55	100	170	200	555

8.10 RECOMMENDATION

As stated in above sections of this report amongst the two alternatives, the Flexible Pavement with Cement treated Base & Granular Subbase (Option-II) has been suggested, for four laning with paved shoulder of project highway.

8.11 PAVEMENT DESIGN SUMMARY

Since the existing pavement is granular base and sub base, the existing pavement is dismantled and flexible pavement with cement treated base & granular subbase shall be provided on the entire carriageway width and the pavement design for the entire project length is as follows:

Table 8.22: Flexible Pavement Layer Thickness for Main Carriageway

Section	Entire Main Carriageway Including Bypass
Design Traffic, MSA	44
CBR, %	8
Pavement Composition	
Pavement Layers	Thickness (mm)
Bituminous Concrete (BC)	40

Dense Bituminous Macadam (DBM)	60
Aggregate Interlayer (AIL)	100
Cement Treated Base (CTB)	165
Granular Sub-base (GSB)	200
Subgrade	500
Total Pavement Thickness*	565

* Excluding Subgrade

Table 8.23: Flexible Pavement Layer Thickness for Slip / Service Roads

Section	Slip/Service Road
Design Traffic, MSA	20
CBR, %	8
Pavement Composition	
Pavement Layers	Thickness (mm)
Bituminous Concrete (BC)	30
Dense Bituminous Macadam (DBM)	55
Aggregate Interlayer (AIL)	100
Cement Treated Base (CTB)	170
Granular Sub-base (GSB)	200
Subgrade	500
Total Pavement Thickness*	540

* Excluding Subgrade

Table 8.24: Rigid Pavement Layer Thickness for Toll Plaza Section

Section	Toll Plaza Section
CVPD in the year of Completion of Construction	1034
CBR, %	8
Pavement Composition	
Pavement Layers	Thickness (mm)
Pavement Quality Concrete (PQC)	280*
Debonding Layer of Polythene Sheet	Provided as per MoRTH Guideline
Dry Lean Concrete (DLC)	150
Granular Sub – Base (GSB)	150
Subgrade	500
Total Pavement Thickness [#]	580

* Thickness is included of two retexturing and grinding to rectify faulting during service life

[#] Excluding Subgrade



CHAPTER - 9

BRIDGES, CULVERTS AND OTHER STRUCTURES

CHAPTER - 9

BRIDGES, CULVERTS AND OTHER STRUCTURES

9.1 GENERAL

The project road starts at Kalavad Jamnagar section of NH-927D & ends at Jamnagar in the state of Gujarat. Detailed inventory and condition survey was carried out along the project stretch, during which 72 culverts (including causeways), 16 Minor bridges and 02 Major bridges were observed as existing Structures to cater for drains, streams & rivers. The proposed structures and rehabilitation scheme for existing structures proposed to be retained has been finalized based on detailed inventory, Horizontal Alignment, Geotechnical investigation, Hydrological study etc.

9.2 DETAILS OF EXISTING STRUCTURES

The recorded data of Bridges (i.e. Inventory and Condition Surveys of Bridges) are given in **Draft Feasibility Report (Appendix-9.1: Bridge Inventory & Condition Survey)**.

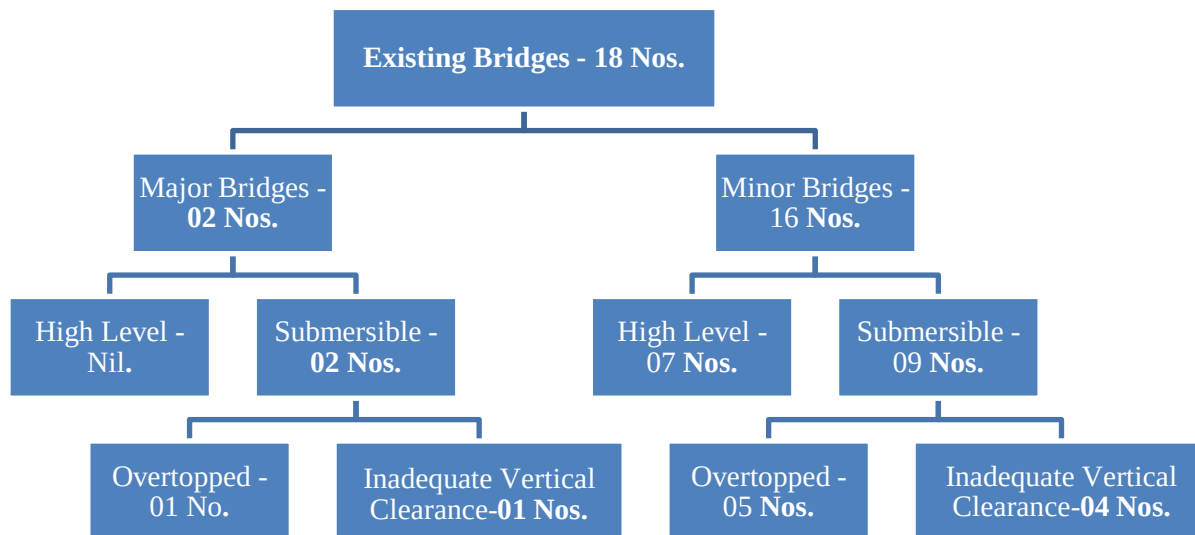


Figure 9.1: Details of Existing Bridges

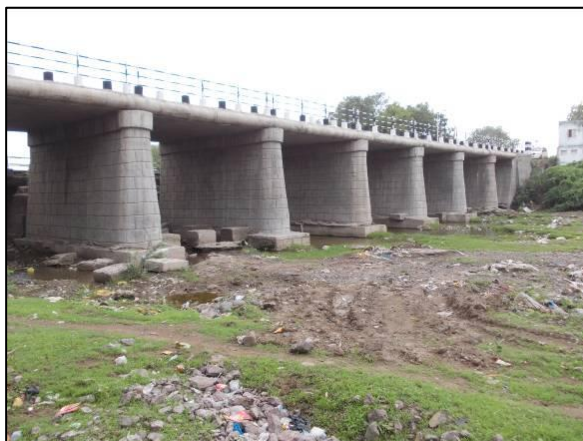
9.3 CONDITION SURVEY OF EXISTING BRIDGES & CULVERTS:

9.3.1 Major Bridges

There are 2 no. existing Major Bridges on the project road catering for two different Rivers:

- **Major Bridge No. 47/2 (Km. 46+270):**

Existing Major Bridge at this location was observed having 9 spans of 7.0m each (c/c of expansion) with RCC Solid Slab Type of superstructure resting on Stone Masonry Sub-Structure. Overall width of Bridge is 8.2m. It seems the bridge was recently constructed with overall condition being fair. However, a submersible bridge with same span arrangement & in poor condition also exists on the adjacent left side of this newly constructed high Level Bridge. RCC slab type superstructure for this submersible bridge was in poor condition with exposed & corroded reinforcement observed at some places along with cracks, scaling etc. Cracks were observed at some places in sub-structure along with damaged railing. Though, the newly constructed bridge had never been overtopped, it seems the new constructed bridge has been designed as a submersible bridge. Also, as per local enquiry, the HFL is marginal & slight below the soffit of newly constructed bridge indicating inadequate vertical clearance.



Existing Span Arrangement



Existing Carriageway



Existing submersible bridge adjacent



Condition of Abutment

Figure 9.2: Major Bridge at Km. 46+270

- **Major Bridge No. 36/2 (Km. 35+625):**

During Inventory, structure No. 36/2 over Moti Phuljar River was observed as a major bridge having 12 span of 5.50 m clear span with RCC slab type of superstructure resting on Stone Masonry Sub-Structure. The structure was found to be in poor condition and submersible in nature. The RCC slab type superstructure was in poor condition with exposed & corroded reinforcement observed at some places along with cracks, scaling etc. Scouring was observed at Pier foundation location with exposed foundation & some cracks were also observed in pier shaft some places.



Existing Submersible bridge



Scouring observed



Damaged Railing



Condition of Bed

Figure 9.3: Major Bridge at Km. 35+625

9.3.2 Minor Bridges

There are 16 existing Minor Bridges lying on the project stretch. The types of superstructures for the Minor Bridges were found to be RCC Solid Slab resting on Stone Masonry Sub-Structure. Some common distresses that were observed was exposed and corroded reinforcement in slabs; spalling of concrete, damaged/ missing railing and growth of vegetation on pier caps and in vent ways, damaged wearing coat, damaged expansion joints & settlement of embankment around abutments etc. Many bridges were found to be submersible in nature and having Guard Stones instead of Railing & Crash Barrier.

Table 9.1: Existing Minor Bridges

S. No.	Structure No.	Location (Km)	Type of Structure	Span Arrangement (m)	Type of Bridge	Condition
1	46/1	45+730	Minor bridge	1 x 9.10 (sk)	High Level	Fair
2	45/4	44+990	Minor bridge	2 x 3.00 (Clear)	High Level	Poor
3	45/2	44+570	Minor bridge	2 x 3.00 (Clear)	High Level	Poor
4	41/1	40+365	Minor bridge	2 x 3.00 (Clear)	High Level	Poor
5	40/3	39+990	Minor bridge	2 x 3.00 (Clear) (Sk)	High Level	Poor
6	40/2	39+520	Minor bridge	4 x 1.50 (Clear)	High Level	Poor
7	39/1	38+580	Minor bridge	5 x 6.50	Submersible	Poor
8	38/2	37+955	Minor bridge	2 x 3.00	High Level	Poor
9	37/2	36+880	Minor bridge	5 x 7.00	Submersible*	Fair
10	29/3	28+800	Minor bridge	3 x 6.80	Submersible	Fair
11	29/2	28+600	Minor bridge	5 x 6.80	Submersible	Poor
12	22/2	21+730	Minor bridge	4 x 6.00	Submersible*	Fair
13	21/1	20+275	Minor bridge	2 x 6.00 (sk)	Submersible	Poor
14	18/3	17+835	Minor bridge	7 x 6.00	Submersible	Poor
15	10/1	9+050	Minor bridge	2 x 5.40	Submersible*	Fair
16	07/2	6+480	Minor bridge	6 x 3.70	Submersible*	Fair

****Never been overtopped but Vertical Clearance found to be inadequate (freeboard above HFL)***

9.3.3 Defect observed in Minor Bridges

i. Major Defects Observed:

Out of 16 minor bridges, 09 bridges were found to be submersible in nature out of which 05 were reported to be overtopped while remaining 04 nos were observed to have inadequate vertical clearance (i.e. free board above HFL). At many locations, scouring was observed with exposed foundation. The major common defects that were observed in most bridges were such as exposed & corroded reinforcement along with spalling concrete in superstructure, cracks observed at many places in sub-structure & superstructure, damaged railing etc.



Submersible Bridge at km 17+835



Submersible Bridge at Km. 28+600



Submersible Bridge at Km 28+800



Submersible Bridge at Km. 38+580

Figure 9.4: Submersible Minor Bridges

ii. Growth of Vegetation obstructing the vent way

At many bridge locations, the growth of vegetation & bushes had been in excess causing & posing as an obstacle to the flow of stream/ drain. Some of such bridge locations are indicated below.



Bridge at Km. 20+275

Figure 9.5: Vegetation in Vent way

iii. Damaged or absence of Railing

At many bridge locations either there had been no railing but guard stones or steel pipe railing. At very few locations, RCC railing was present but in damaged condition with exposed & corroded reinforcement posing threat to safety of pedestrians and vehicles.



Bridge at Km 21+730



Bridge at Km 28+600

Figure 9.6: Damaged Railing/ Parapet

iv. Exposed and Corroded Reinforcement

Exposed and Corroded reinforcement at soffit of superstructure & pier caps was found at some of the bridge locations along with cracks & spalling of concrete, which may be due to inadequate cover to reinforcements.



Bridge at Km 21+730

Figure 9.7: Exposed & Corroded Reinforcements

v. Condition of Expansion joint

Existing Expansion joints were generally found to be buried and in fair condition. At most of the locations, filler type of expansion joint was expected as RCC solid slab type superstructure exists in most of the bridges.

vi. Wearing coat

At most of the Bridge locations, wearing coat was found to be of bituminous, which was found to be in distressed state like scaling and undulations etc. However, at some bridge locations, it seems as if new wearing coat had been laid recently.



Bridge at Km 38+580

Figure 9.8: Type & condition of Wearing Coat

vii. Scouring observed at Sub Structure

At some of the Bridge locations, Scouring was observed at the Piers/ Abutments hampering & hence, exposing foundation.



Bridge at Km 39+520



Bridge at Km 37+955

Figure 9.9: Scouring at Sub Structure

9.3.4 Inventory & Condition Survey for Culverts

The similar procedures were adopted for the inventory and condition surveys for cross-drainage structures as per guidelines stipulated in IRC-SP: 19-2001. The existing culverts observed along the project road are mainly of four types viz. RCC Slab culverts, Pipe culverts, and Causeways (Flush). The structural condition of pipe culvert is generally fair, except few partially choked or buried culverts due to heavy vegetation. Most of the slab culverts are in poor condition. Some common distresses observed were damaged parapets, cracked/ damaged headwalls, abutments and return walls, corroded exposed reinforcement, insufficient waterway etc.

The recorded data of Culverts (i.e. Inventory and Condition Surveys of Culverts) are given in **Draft Feasibility Report (Appendix-9.2: Culvert Inventory)**.

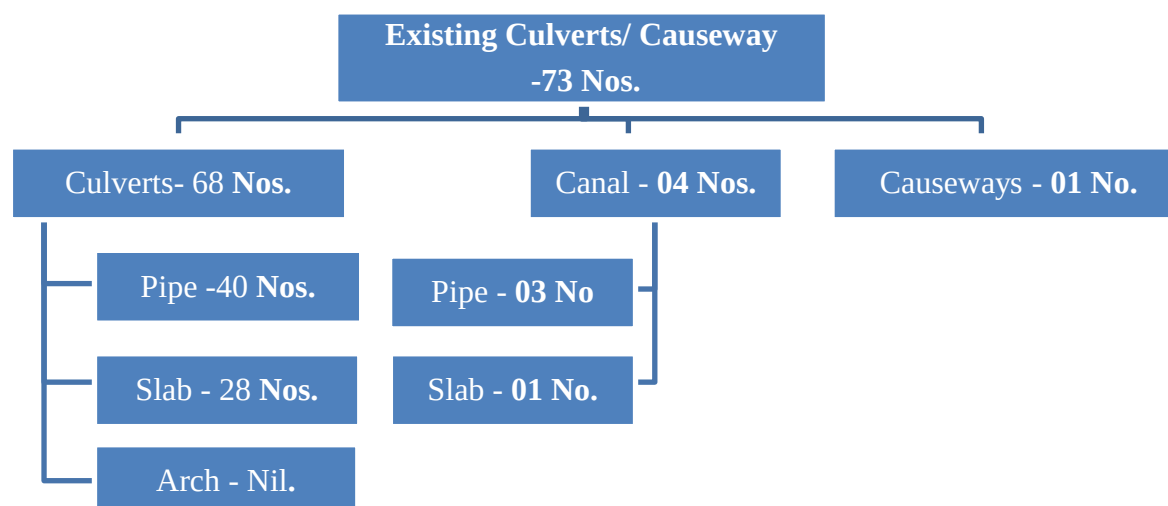


Figure 9.10: Details of Existing Culverts

9.3.4.1 Defect observed in Pipe Culverts

Some common defects like Buried/ Choked pipes due to Vegetation, inadequate waterway, etc. were observed during the detailed condition survey of pipe culverts.



Choked Pipe Culvert at Km 31+325

Figure 9.11: Choked Pipe Culverts

9.3.4.2 Defects observed in Slab Culverts

Following common defects were observed during the visual condition survey of slab culvert

i. Exposed & Corroded Reinforcement:

Exposed and corroded reinforcement along with spalling of concrete at soffit of deck was found at some of slab culvert locations which may be due to inadequate cover to reinforcements.



Culvert at Km 37+330

Figure 9.12: Exposed & Corroded Reinforcement in Slab Culverts

ii. Damaged Parapet Wall:

Parapet was either found to be damaged or absent at some of the Slab culvert locations.



Culvert at Km 28+275



Culvert at Km 31+770

Figure 9.13: Damaged Parapet in Culverts

iii. Scouring at Sub-Structure:

Sub Structure & Bed protection was found to be in severely damage condition at some culvert locations due to scouring.



Damaged Bed at Km 8+730

Figure 9.14: Scouring observed in Slab Culverts

9.3.4.3 Defects observed in Slab Culverts

A vented causeway having 5 nos of Pipe of 900mm dia was observed to be situated at Km 12+500 on the project road. This causeway was found to exist in low lying & submersible area. Detail analysis & hydrological investigations shall be carried out to envisage a high level structure (either a culvert or a bridge) against the exiting causeway.



Causeway at Km 12+500



Causeway at Km 12+500

Figure 9.15: Defects observed in Slab Culverts

9.4 PROPOSED STRUCTURES

As per the proposed Alignment along the Project Stretch 05 Major bridges, 14 Minor bridges, 02 Minor Bridges on Service road and 77 culverts are proposed in which 27 culverts will be reconstructed , 31 culverts are to be widened and 19 culverts are to newly constructed on bypasses and realignment. All Major and Minor Bridges have been proposed to four lane configurations as per applicable manual of specifications (i.e. IRC: SP: 84-2014 & IRC: SP: 73-2015).

9.4.1 Major Bridges

Amongst existing 02 Major Bridges, both are proposed to be abandoned due to proposed Bypass/ realignments. However, 02 new Major Bridge are proposed in Bypass/ realignments against the corresponding respective stream of the existing Major bridges abandoned along with 01 additional proposed in Kalavad bypass too.

02 existing Minor Bridges (at km 17+835 & km 38+580) is proposed to be reconstructed due to being submersible in nature.

9.4.2 Minor Bridges

Amongst the existing Minor Bridges (16) on the Existing Project Stretch, 11 have been proposed for Reconstruction as New High Level Bridges (02 as Major Bridge & 09 as Minor Bridge), while 03 are abandoned due to proposed Bypass/ Realignments. Remaining 02 existing Minor Bridge has been realigned & proposed for New Construction as High Level Minor Bridges considering geometry improvement for proposed alignment. In addition to

above, 02 New minor bridge is proposed in Bypass while 01 is proposed against the causeway at Km 12+500 in minor realignment.

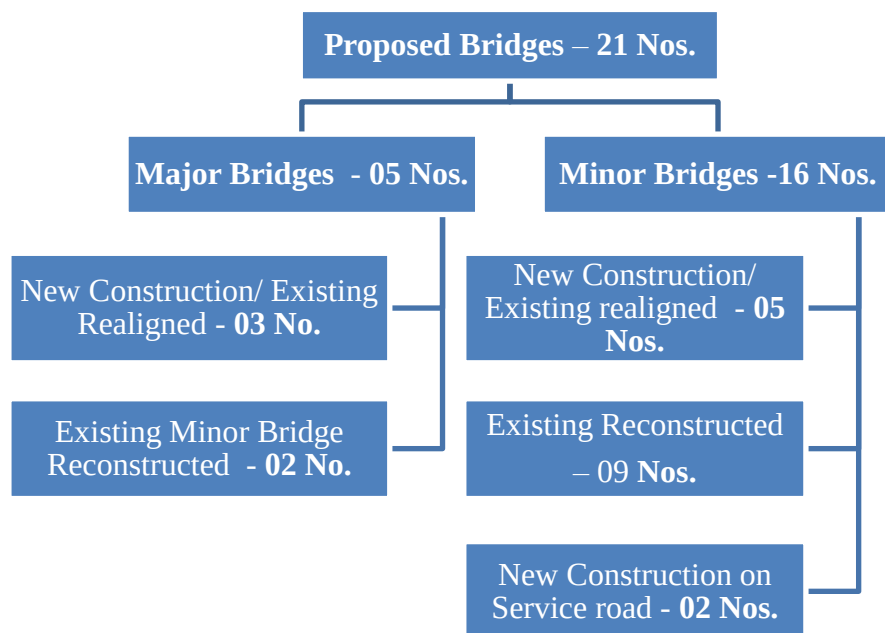


Figure 9.16: Summary of Proposed Bridges

9.5 IMPROVEMENT PROPOSALS FOR MAJOR BRIDGES

05 Nos. Major Bridges are recommended along the proposed alignment. All Major Bridges have been proposed to accommodate width as per 4 laning manual of specifications. The proposals (with details) for the existing & proposed major bridges are as follows.

1) Existing Major Bridge at Km 46+270 (Ch. 6.111)

The Major Bridge in Kalavad at Km 46+270 is proposed to be abandoned due to proposed Kalavad bypass. A New high-level bridge of 4 Lane configurations is proposed on bypass corresponding to the same river as that of existing.

2) Existing Major Bridge at KM 35+625 (Ch. 16.354)

On the basis of detailed Hydrological Investigations, local enquiry & existing bridge being submersible, a new high level major bridge is proposed in realignment. The existing Bridge is having RCC Solid Slab type of Super Structure resting on Stone masonry Wall Type Sub-Structure.

3) Proposed Major Bridge at Ch. 0+376 (Kalavad bypass)

New Major Bridge is proposed on Kalavad Bypass due to presence of stream which is found to run parallel to the existing road but crosses the proposed alignment (i.e. Kalavad Bypass at Ch. 0.390).

4) Proposed Major Bridge at KM 38+580 (Ch. 13.785)

01 existing Minor Bridge at Km 38+580 is recommended to be reconstructed as New High Level Major Bridge due to its submersible nature. The existing Bridge is having RCC Slab type of Super Structure resting on Stone masonry Sub-Structure.



Existing Span Arrangement



Upstream Location

5) Proposed Major Bridge at KM 17+835 (Ch. 33.740)

Similarly, 01 existing Minor Bridge at Km 17+835 is recommended to be reconstructed as New High Level Major Bridge due to its submersible nature. The existing Bridge is having RCC Slab type of Super Structure resting on Stone masonry Sub-Structure.



Existing Span Arrangement



Upstream Location

Table 9.2: Improvement Proposals for Major Bridges

S. No.	Location (Km)	Design Ch.	Existing type (m)	Existing Span (m)	Proposal	Proposed Span (m)	Proposed Super-structure
1	-	0.376	Major bridge	-	New Construction (Bypass)	7 x 59.779 (Skew)	PSC Girder
2	46+270	6.111	Major bridge	9 x 7.00	New Construction (Bypass)	3 x 25.0	PSC Girder
3	38+580	13.785	Major bridge	5 x 6.50	Reconstruction	3 x 20.0	RCC Girder
4	35+625	16.354	Major bridge	12 x 6.8	New Construction (Realignment)	5 x 40.0	PSC Girder
5	17+835	33.740	Major bridge	7 x 6.00	Reconstruction	3 x 22.987 (Skew)	RCC Girder

9.6 IMPROVEMENT PROPOSALS FOR MINOR BRIDGES

16 Minor Bridges are recommended along the proposed alignment in line with manual of specification & standards for four laning of Highways (as per IRC: SP: 84-2019) & as elaborated in subsequent paras.

9.6.1 Minor Bridges on Service Road

02 nos. of Minor Bridges are proposed on Service road due to lying in approaches of grade separated structures proposed in Kalavad bypass:

Table 9.3: List of Minor Bridges proposed on Service Road

S. No.	Location (Km)	Design Ch.	Proposed Span Arrangement (m)	Proposed type of Superstructure	Proposed Width (m)
1	Kalavad bypass	1.186	1 x 20.0	RCC Girder	2 X 9.5
2	Kalavad bypass	8.659	2 x 10.0	RCC Slab	2 X 9.5

9.6.2 Reconstruction of Existing Minor Bridges

09 existing Minor Bridges have been recommended to be reconstructed as new high Level Minor Bridges, out of which 02 are being reconstructed due to their Submersible nature, 03 are reconstructed considering existing condition of the bridges & type of substructure; while the remaining 04 Minor Bridges are being reconstructed due to inadequate vertical clearance/freeboard above HFL being observed. The list of such bridges has been tabulated below:

Table 9.4: List of Minor Bridges recommended for reconstruction

S. No.	Location (Km)	Design Ch.	Existing Span (m)	Proposed Span Arrangement (m)	Proposed type of Superstructure	Proposed Width (m)
1	40+365	11+987	2 x 3.00 (Clear)	1 x 8.0	RCC Box	2 x 13.1
2	39+990	12+364	2 x 3.00 (Clear) (Sk)	1 x 8.0 (Skew)	RCC Box	2 x 13.1
3	39+520	12+838	4 x 1.50 (Clear)	1 x 8.0	RCC Box	2 x 13.1
4	36+880	15+461	5 x 7.00	3 x 15.0	RCC Girder	2 x 13.1
5	28+600	23+145	5 x 6.80	4 x 10.0	RCC Slab	2 x 13.1
6	21+730	29+915	4 x 6.00	3 x 10.0	RCC Slab	2 x 13.1
7	20+275	31+337	2 x 6.00 (sk)	3 x 8.0 (Skew)	RCC Box	2 x 13.1
8	9+050	42+216	2 x 5.40	2 x 10.0	RCC Slab	2 x 13.1
9	6+480	44+812	6 x 3.70	3 x 7.0 (Skew)	RCC Box	2 x 13.1



Bridge at Km 36+880



Bridge at Km 28+600



Bridge at Km 21+730



Bridge at Km 9+050

9.6.3 Realignment of Existing Minor bridges

02 existing Minor Bridge at Km 28+800 & km 37+955 have been recommended to be realigned as New 4 Lane Minor Bridges considering geometry Improvement for proposed Alignment.

Table 9.5: List of Minor Bridges realigned as New 4 lane Minor Bridges

S. No.	Location (Km)	Design Ch.	Span Arrangement (m)	Proposed Span Arrangement (m)	Proposed type of Superstructure	Proposed Width (m)
1	37+955	14+361	2 x 3.0	1 x 8 (sk)	RCC Box	2 x 13.1
2	28+800	22+977	3 x 6.80	3 x 10.0 (Sk)	RCC Slab	2 x 13.1



Bridge at Km 28+800

9.6.4 Minor bridges proposed in bypass

02 Minor Bridges has been proposed in Kalavad bypass as new 4 lane minor bridge. List of such bridges are as given below:

Table 9.6: List of Minor Bridges proposed in bypass

S. No.	Location (Km)	Design Ch.	Proposed Span Arrangement (m)	Proposed type of Superstructure	Proposed Width (m)
1	Kalavad bypass	1.200	1 x 20.0	RCC Girder	2 x 11
2	Kalavad bypass	8.660	2 x 10.0	RCC Slab	2 x 11

9.6.5 Minor bridges proposed over causeways

01 New High level minor bridge has been proposed on realignment against the causeway found at Km 12+500 on the existing road.

Table 9.7: List of Minor Bridges proposed against causeway

S. No.	Location (Km)	Design Ch.	Span Arrangement (m)	Proposed Span Arrangement (m)	Proposed type of Superstructure	Proposed Width (m)
1	12+500	38.764	6 x 0.90	5 x 10.0 (Skew)	RCC Slab	2 x 13.1



Causeway at Km 12+500



Causeway at Km 12+500

Table 9.8: Improvement proposals for Minor Bridges

S. No.	Location (Km)	Design Ch.	Existing Span (m)	Proposal	Proposed Span	Proposed Type of superstructure	Proposed Width
1	Kalavad bypass	1+186	-	New Construction (Bypass)	1 x 20.0	RCC Girder	2 x 11
2	Kalavad bypass	8+659	-	New Construction (Bypass)	2 x 10.0	RCC Slab	2 x 11
3	Kalavad bypass	1+186	-	New Construction (Bypass) on Service Road	1 x 20.0	RCC Girder	2 x 11
4	Kalavad bypass	8+659	-	New Construction (Bypass) on Service Road	2 x 10.0	RCC Slab	2 x 11
5	40+365	11+987	2 x 3.00 (Clear)	Reconstruction	1 x 8m	RCC Box	2 x 13.10
6	39+990	12+364	2 x 3.00 (Clear) (Skew)	Reconstruction	1 x 8m	RCC Box	2 x 13.10
7	39+520	12+838	4 x 1.50 (Clear)	Reconstruction	1 x 8m	RCC Box	2 x 13.10
8	37+955	14+361	2 x 3.00	New Construction	1 x 8m	RCC Box	2 x 13.10
9	36+880	15+461	5 x 7.00	Reconstruction	3 x 15m	RCC Girder	2 x 13.10
10	28+800	22+977	3 x 6.80	New Construction	3 x 10m	RCC Slab	2 x 13.10
11	28+600	23+145	5 x 6.80	Reconstruction	4 x 10m	RCC Slab	2 x 13.10
12	21+730	29+915	4 x 6.00	Reconstruction	3 x 10m	RCC Slab	2 x 13.10
13	20+275	31+337	2 x 6.00 (Skew)	Reconstruction	3 x 8m	RCC Box	2 x 13.10
14	12+500	38+764	6 x 0.90	New Construction	5 x 10m	RCC Slab	2 x 13.10
15	9+050	42+216	2 x 5.40	Reconstruction	2 x 10m	RCC Slab	2 x 13.10
16	6+480	44+812	6 x 3.70	Reconstruction	3 x 7.0	RCC Box	2 x 13.10

9.7 IMPROVEMENT PROPOSALS FOR GRADE SEPARATED STRUCTURES

01 Flyover, 02 vehicular Underpasses & 01 LVUP are recommended along the proposed alignment in line with manual of specification & standards for four lanning of Highways (as

per IRC: SP: 84-2014).

Table 9.9: List of Grade Separated Structures

S. No.	Location (Km)	Design Ch.	Proposed Span Arrangement (m)	Proposed type of Superstructure
1	Kalavad bypass	1+216	2x10.0x5.5 clear	VUP
2	Kalavad bypass	4+600	2x12.0x5.5 clear	VUP
3	Kalavad bypass	8+255	2x12.0x5.5 clear	VUP
4	4+700	46+670	(2x30m) x5.5 clear	Flyover

9.8 IMPROVEMENT PROPOSALS FOR EXISTING CULVERTS

77 culverts are proposed along the project road including additional culverts. The improvement proposals for existing culverts are proposed for 4 lane carriageway (as per the Manual of Specifications).

1. There are 25 existing culverts in reconstruction excluding canal structures (17 slab type, 08 pipe culvert). These culverts observed along the project road are mainly of poor condition, inadequate waterway and has been recommended for reconstruction.
2. Out of 04 existing Canal Culverts (03 Pipe & 01 Slab), 01 (pipe) is proposed to be widened & 02 (pipe) are proposed for reconstruction. Remaining 01 culvert (Slab) is abandoned & proposed for new construction on realignment as RCC Box culvert.
3. 30 Nos of Culverts (25 Pipe culverts & 05 Slab Culverts) are in good condition & have been recommended for widening w.r.t. Schedule of TCS.
4. 16 new culverts have been proposed on bypasses & realignments (12 Pipe & 05 Box)
5. Some pipes were found partly choked. The pipes having inadequate waterway has been recommended for reconstruction with increased waterway.
6. All new pipe culverts have been recommended with 1.2 m diameter pipe as per Manual of Specification.
7. A reinforcement concrete pipe for culverts shall be of NP 4 type, conforming to the requirements of IS: 458.
8. All Culverts are proposed for full formation width of the Roadway.
9. At most of the locations efforts have been made to replace all existing Slab Culverts with RCC Box Culverts as the existing Road Level will be raised. Although these proposals are tentative & liable to change depending on the finalization of Vertical

Report & after submission of Feasibility report.

10. New Box type culverts has been recommended with min. 2 m clear span and min. 1.5 m vertical clearance as per IRC:SP:13-2004.
11. In case of culverts whose bed and floor have scoured off severely and considerable afflux is observed, the same will be replaced with new culverts having adequate vents.
12. In new alignments, sufficient numbers of balancing culverts are to be provided wherever alignment crosses through flat agricultural fields and lies in close vicinity to high embankments of proposed high level bridges. The location of these culverts shall be finalized depending upon the final & approved alignment.

9.8.1 Summary of proposals for pipe Culverts

- (a) Existing Pipe Culvert to be widened

Table 9.10: Existing Pipe Culvert to be widened

Item	Descriptions
Nil	

- (b) Existing Pipe Culvert to be reconstructed

Table 9.11: Existing Pipe Culvert to be reconstructed

Item	Descriptions
Single Pipe Culvert	1 x 1.20 = 17 No.
Double Pipe Culvert	1 x 1.20 = 13 No.
Three Pipe Culvert	3 x 1.20 = 03 Nos.
Four Pipe Culvert	4 x 1.20 = 03 Nos.

- (c) New proposed Pipe Culverts on Existing Stretch

Pipe culverts are proposed on Bypasses & realignments as below:

Item	Descriptions
Single Pipe Culvert	1 x 1.2 = 07 Nos.
Double Pipe Culvert	2 x 1.2 = 04 Nos.
Triple Pipe Culvert	3 x 1.2 = 01 Nos.

Apart from above & Depending upon the detailed Site Investigations, waterlogged areas & low lying areas throughout the project Stretch, minimum of 01 culvert shall be provided

within successive KM range having no culverts. However, the numbers of culverts, actual location, span and type of culvert shall be finalized after detailed inspection of final alignments and marking of proposed centre line at site.

9.8.2 Summary of proposals for Slab Culverts

- (a) Slab Culvert to be reconstructed

Table 9.12: Slab Culvert to be reconstructed as Box Culvert

Item	Descriptions
Slab culvert to be Reconstructed as Box Culvert	1 x 2.0 = 03 Nos.
	1 x 2.50 = 01 Nos.
	1 x 3.0 = 03 Nos.
	1 x 3.50 = 01 Nos.
	1 x 4.0 = 05 Nos.
	1 x 5.0 = 08 Nos.
	1 x 6.0 = 01 Nos.

- (b) Slab Culvert to be widened

Table 9.13: Slab Culvert to be widened

Item	Descriptions
Nil	

9.8.3 Summary of Proposals for Existing Canal Culverts

- (a) Existing Canal Pipe Reconstructed

Table 9.14: Existing Canal Pipe Reconstructed

Item	Descriptions
Nil	

- (b) Existing Canal Pipe Widened

Table 9.15: Existing Canal Pipe Widened

Item	Descriptions
Nil	

(c) Existing Canal Slab Realigned

Table 9.16: Existing Canal Slab realigned

Item	Descriptions
Nil	

9.8.4 Summary of Proposals for New Box Culverts

(a) New Box Culverts proposed on Bypass realignments

Table 9.17: New Box Culverts

Item	Descriptions
New Box Culverts proposed	1 x 2.0 = 01 No.
	1 x 3.0 = 03 No.
	1 x 4.0 = 01 No.
	1 x 5.0 = 02 No.

9.9 SUMMARY OF IMPROVEMENT PROPOSALS

Table 9.18: Improvement Proposals for Major Bridges

Total number of proposed bridges	Existing Major bridge realigned due to geometry & curve improvement	Existing reconstructed due to submersible/ inadequate freeboard over HFL	Existing Minor Bridges reconstructed as Major Bridges due to submersible	Proposed in Bypass/ Major realignments
05	00	00	02	03

Table 9.19: Improvement Proposals for Minor Bridges

Total number of proposed bridges	Proposed in Bypass/ Major Realignment	Reconstruction		Realigned	Realigned
		As Minor Bridge	As Major Bridge	As Minor Bridge	Causeway as minor bridge
16	02 MCW + 02 Service road	09	02	02	01

Table 9.20: Improvement Proposals for Culverts

Total Culverts	Culverts to be widened			Culverts to be reconstructed					Vented Causeways to be realigned as	Culverts to be realigned / New		
	Pipe	Slab	Canal (Pipe)	Pipe	Slab	Box	Canal (Slab)	Canal (Pipe)	Minor Bridge	Pipe	RCC Slab to RCC Box	Canal (box)
77	NIL			36	22	00	00	00	01	12	07	00

9.10 REPAIRS AND REHABILITATION OF STRUCTURES (BRIDGES & CULVERTS)

Based on the defects observed during detail inventory & condition survey, a comprehensive repair and rehabilitation plan is prepared for bridges & culverts proposed to be widened/retained:

1. Expansion joints shall be made functional.
2. Existing wearing coats shall be replaced with new wearing coat.
3. Existing bridges having distorted camber need to be modified with a provision of bi-directional camber.
4. Some plastering work shall be done in the cracked/distresses portions of the existing bridges
5. Damaged Existing railings/ parapet shall be replaced with crash barriers.
6. Vegetation shall be removed from the structures; vent way and revetments around abutments.
7. Damaged stone pitching shall be replaced/ rehabilitated on embankments.
8. Approach slab shall be constructed on both sides.
9. Existing drainage spout shall be cleaned. (Fill up the hole in deck slab around spout. Replace drainage spouts with short or missing down take pipes. Install missing drainage spouts at locations where they are missing/ not provided at all originally).



CHAPTER - 10
HYDROLOGY AND DRAINAGE SYSTEM

CHAPTER - 10

HYDROLOGY AND DRAINAGE SYSTEM

10.1 GENERAL

Main objective of hydrology is to determine anticipated flood and other parameters such as Design Discharge, Flow Velocity, HFL, and Scour Depth. Bridge structure shall be designed so as to cater for the anticipated floods without endangering the structure.

Hydrological inputs play a vital role in a water related structure at all stages i.e. in planning, designing, execution and operation of the system. The need for assessment of peak design discharge at a Project site based on physiographic and meteorological parameters/data through appropriate method/model, (which is technical sound and economical viable) is the main aim of assessment of reasonable peak design discharge at the structure point.

The hydrological and hydraulic studies shall be carried out in accordance with IRC Special Publication No. 13-2004 (“Guidelines for the Design of Small Bridges and Culverts”) and IRC: 5-1998 (“Standard Specifications & Code of Practice for Road Bridges, Section-I (“General Feature of Design”) and specific Flood Estimation Report for particular Sub-Zone published by the Directorate of Hydrology (Small Catchment) Central Water Commission, New-Delhi, Government of India. **As per these CWC report, the project lies in Zone 3(a).** Detailed Hydrological Investigations for all Structures shall be submitted in Hydrology Report.

10.2 TOPOGRAPHICAL AND HYDROLOGICAL FEATURES OF THE REGION

The project stretch from Dhoraji to Jamnagar lies in Sub Zone 3(a) of Mahi & Sabarmati River (as per CWC Report). This Mahi & Sabarmati zone covers more than half of the Gujarat with most of the drainage area being covered by Mahi & Sabarmati River. The topography of this region is mainly constituted of upper reaches draining the parts of Aravali ranges, Vindhya ranges & Malwa Plateau, Gujarat Plains & Kathiawar peninsula. The soil around the project stretch is medium black.

The normal annual rainfall in this region varies from 40cm to 60cm. The major source of rainfall is south-west monsoon during June to September. About 90% of the annual rainfall occurs during the monsoon season.

10.3 DATA COLLECTION

Inputs in the study including the field survey data, bridge inventory records, geo-technical investigations, storm duration, rainfall statistics, top soil characteristics, vegetation cover etc and information gathered during field visit plays vital role in determining the design discharge at each structure site through various available approaches.

Regarding the same, the various essential data are collected for hydrological investigation. Catchment area is calculated from the Topo sheets available on a scale of 1:50000 for small catchments and 1:250000 for large catchments. Highest flood level was observed and measured during site visit supplemented by local enquiry. Attempts are & shall be made to collect more data of existing bridges and their performance during past floods from the Governing Departments.

10.4 METHODOLOGY ADOPTED FOR PEAK DISCHARGE COMPUTATIONS

The most common methods to estimate the flood discharge are as under:

- a) Empirical Method
- b) Rational Method
- c) Unit Hydrograph
- d) Area Velocity Method

a) Empirical Method (Dicken's):

Dicken's Formula is used for the project area, as per IRC SP-13:

$$Q = C M^{3/4}$$

Where, Q = Peak run-off in m³/sec

M = Catchment area in Sq.Km.

C = Coefficient of run-off, depends upon annual rainfall

The catchment area M is determined from the Topo sheet, Coefficient of run-off 'C' is determined from IRC SP-13 depending upon the intensity of rainfall. This formula gives a simplified approach and results are approximate. Comparisons are made with alternative methods for important structures.

b) Flood assessment based on rational approach :

The rational formula for assessment of peak discharge from project catchment takes into account rainfall, runoff under various circumstances, and time of concentration and critical intensity of rainfall. Basic formulae are as under:

$$\text{One hour rainfall (I}_o\text{), } I_o = (F/T) * (T+1) / (1+1)$$

$$\text{Critical rainfall intensity } I_c = I_o * (2 / (1+tc))$$

$$\text{Discharge, } Q = 0.028 * P * f * A * I_c$$

$$\text{Time of concentration, } tc = (0.87 * L^3 / H) 0.385$$

Where,

t_c = Time of concentration i.e. time taken by runoff from farthest point on the periphery of catchment (hrs)

I_o = One hour rainfall in cm

I_c = Critical intensity of rainfall in cm per hour

P = Coefficient of runoff for the catchment characteristics (Ref: Table - 4.1, P-13 and IRC SP: 13-2004)

A = Catchment area in hectare

Q = Maximum discharge in cumecs

L = Distance from the critical point to the structure (Length of path in Km)

H = The difference in level from the critical point to the structure in meter

F = Maximum rain fall in mm

T = Duration of storm in hours

f = A fraction of maximum point intensity at the centre of the storm and related with the catchment area (Determined from Fig. 4.2, Page-14, IRC: SP: 13-2004.)

In the present study, storm rainfall and storm duration data of 100 Years return period is utilized from design flood hydrograph of nearby project sites, developed on the basis of Hydro-meteorological studies as per relevant Flood estimation reports of the particular region/area.

c) Unit Hydrograph approach for assessment of design flood discharge:

The unit hydrograph (UG) of a drainage basin is defined as the direct runoff (outflow) hydrograph resulting from one unit of effective rainfall which is uniformly distributed over the basin at a uniform rate during the specified period of time known as unit time or unit duration.

This method is applicable for Catchment area varying between 20-25 Sq. Km to 2500-5000 Sq Km. In present study, the design discharge calculations are done for 100 Years return period as stipulated in Manual of specifications.

d) Area Velocity Method

The area velocity method uses Manning's formula (as per IRC SP: 13-2004 manually or using HEC-RAS Software) for calculating flow velocity as under.

$$Q = A \cdot V$$

$$V = (1/n) R^{2/3} S^{1/2}$$

Where,

Q = Peak run-off in m^3/sec

A = Cross sectional area of flow

V = Velocity of flow

n = Rigidity coefficient

R = Hydraulic mean radius = A / P

P = Wetted perimeter

S = Energy slope which may be taken equal to bed slope

Cross sections of the streams are taken both upstream and downstream at a distance as specified in IRC SP -13 by Topo survey in the field. Longitudinal slope of the bed is also calculated by taking long section over a reasonably long reach of the stream. HFL was also observed in the field by flood marks and local enquiry. This formula gives fairly reasonable estimation of flood discharge.

10.5 DESIGN DISCHARGE FOR BRIDGES

Design discharge is fixed as per provisions of Clause 6.2 of IRC SP-13. The values of peak discharge calculated by above methods are compared. The highest of these values is adopted as design discharge, provided it does not exceed the next highest discharge by more than 50 percent. If it does, restrict it to that limit. The design discharge adopted for the Bridges are given below:

Table 10.1: Design Discharge & Waterway for Bridges along the proposed alignment

S. No.	Location/ Ex. Ch.	Design Ch.	Proposed type	Proposed Span/ Waterway	Discharge (cumecs)
1	Kalavad	0+376	Major bridge	7 x 59.779 (Skew)	935.00
2	Kalavad	1+186	Minor Bridge	1 x 20.0	41.00
3	Kalavad	6+111	Major bridge	3 x 25.0	1454.00
4	Kalavad	8+659	Minor Bridge	2 x 10.0	28.318
5	40+365	11+987	Minor Bridge	1 x 8.0	19.258
6	39+990	12+364	Minor Bridge	1 x 8.0 (Skew)	11.867
7	39+520	12+838	Minor Bridge	1 x 8.0	19.267
8	38+580	13+785	Major bridge	3 x 20.0	447.566
9	37+955	14+361	Minor Bridge	1 x 8.0 (Skew)	41.763
10	36+880	15+461	Minor Bridge	3 x 15.0	230.108

S. No.	Location/ Ex. Ch.	Design Ch.	Proposed type	Proposed Span/ Waterway	Discharge (cumecs)
11	35+625	16+354	Major bridge	5 x 40.0	2294.572
12	28+800	22+977	Minor Bridge	3 x 10.0 (Skew)	231.036
13	28+600	23+145	Minor Bridge	4 x 10.0	411.326
14	21+730	29+915	Minor Bridge	3 x 10.0	165.950
15	20+275	31+337	Minor Bridge	3 x 8.0 (Skew)	102.865
16	17+835	33+740	Major bridge	3 x 22.987 (Skew)	609.556
17	12+500	38+764	Minor Bridge	5 x 10.0 (Skew)	535.087
18	9+050	42+216	Minor Bridge	2 x 10.0	187.096
19	6+480	44+812	Minor Bridge	3 x 7.0	209.751

10.6 DESIGN HFL

The design HFL (without afflux) adopted for the Bridges are given below:

Table 10.2: Design HFL & Afflux for Bridges along the proposed alignment

S. No.	Location (Km)	Design Ch.	Proposed type	HFL (without Afflux)	Afflux
1	Kalavad	0+376	Major bridge	101.000	0.015
2	Kalavad	1+186	Minor Bridge	100.704	0.400
3	Kalavad	6+111	Major bridge	84.115	1.358
4	Kalavad	8+659	Minor Bridge	105.100	0.212
5	40+365	11+987	Minor Bridge	88.891	0.472
6	39+990	12+364	Minor Bridge	88.550	0.600
7	39+520	12+838	Minor Bridge	85.850	0.155
8	38+580	13+785	Major bridge	81.800	0.081
9	37+955	14+361	Minor Bridge	83.903	0.088
10	36+880	15+461	Minor Bridge	81.600	0.030
11	35+625	16+354	Major bridge	80.800	0.372
12	28+800	22+977	Minor Bridge	65.050	1.121
13	28+600	23+145	Minor Bridge	64.705	1.453

S. No.	Location (Km)	Design Ch.	Proposed type	HFL (without Afflux)	Afflux
14	21+730	29+915	Minor Bridge	54.000	0.605
15	20+275	31+337	Minor Bridge	58.550	0.657
16	17+835	33+740	Major bridge	38.100	1.616
17	12+500	38+764	Minor Bridge	34.255	0.097
18	9+050	42+216	Minor Bridge	23.780	1.383
19	6+480	44+812	Minor Bridge	20.250	1.053

10.7 RECOMMENDED WATERWAY OF BRIDGE

The waterway proposed for bridges recommended for new construction & reconstructions are mentioned in **Table 10.1**.

10.8 SCOUR DEPTH

Determination of scour depth is important factor for deciding depth of foundation and shall be derived as per Cl. 703.2 of IRC: 78 – 2014 according to which:

$$d_{sm} = 1.34 * (D_b^2 / K_{sf})^{1/3}$$

Where

dsm = Mean depth of scour

Db = Design discharge per meter width of effective waterway

Ksf = Silt factor of bed material,

The maximum depth of scour below the highest flood Level (HFL) for the design of piers and abutments located in a straight reach and having individual foundations without any floor protection works is taken as under.

In the vicinity of piers = 2.0 dsm

Near abutments = 1.27 dsm

The scour depth calculated in present Hydrology is tentative in absence of geotechnical investigations. Thus, final scour depth shall be provided after geotechnical investigations results.

10.9 COMPUTATION OF AFFLUX

The Afflux at the bridge is heading up of the water surface caused by it. It is measured by the difference in levels of water surface at upstream & downstream. When the waterway area of

the opening of the bridge is less than the unobstructed natural waterway area of the stream i.e. when the bridge contracts the stream, afflux occurs which is calculated as stipulated in IRC: SP-13 & other sound practices. The afflux determined by the hydrological study for the Bridges are given in Table 10.2.

10.10 VERTICAL CLEARANCE

Provision of Vertical clearance in bridges above HFL is kept as per IRC SP-13, Clause 12.3 as under.

Table 10.3: Vertical Clearance

Discharge in m³/s	Minimum Vertical clearance in m
Upto 0.30	0.15
Above 0.3 and upto 3.0	0.45
Above 3 and above 30	0.6
Above 30 and upto 300	0.9
Above 300 and upto 3000	1.2
Above 3000	1.5

However, for clarity, it is emphasized that no changes are envisaged in existing structures unless reconstruction or new construction is involved.



CHAPTER - 11

**ENVIRONMENTAL SCREENING AND
PRELIMINARY ENVIRONMENT ASSESSMENT**

CHAPTER - 11

ENVIRONMENTAL SCREENING AND PRELIMINARY ENVIRONMENTAL ASSESSMENT

11.1 INTRODUCTION

The Indian Academy of Highway Engineers (IAHE) has been entrusted with the assignment of Project Management Consultancy Phase I including preparation of Detailed Project Report of selected stretches/corridors of National Highways for Two/Four laning with paved shoulder configuration in the States of Maharashtra, Gujarat, Chhattisgarh, Rajasthan and Karnataka. Under this phase, Government of India felt the necessity of partially access controlled corridor between Kalavad and Jamnagar section of NH 927D through upgradation to 4-lane in the state of Gujarat. The project road starts from km 50+925 at Kalavad and end at km 3+720 at Jamnagar section of National highway 927D. The Proposed length of the project highway (Package-2) is 47.572 km.

The proposed improvements of Dhoraji-Kalavad highway aims for:

Important Interstate connectivity between Dhoraji to Kalavad

- Connectivity to many headquarters/taluka place developed as business centre and Agriculture Marketing Yard.
- Better connectivity to important town Kalavad and Jamkondarna along the project Corridor.
- Provide a platform for better economic and Industrial growth of the region.

IAHE has invited proposal for carrying out Feasibility study and detailed project preparation for upgrading to 4 lanes with paved shoulders configuration of Kalavad-Jamnagar section of NH-927D in the state of Gujarat (Package No:NH/IAHE/18).This project is under category-I.

11.1.1 Need of the Study

Development of highway projects is generally intended to improve the economic and social welfare of the people. At the same time it may also create adverse impact on the surrounding environment.

People and properties may be in the direct path of road works are affected. The environmental impact of highway projects include damage to sensitive eco-systems, soil erosion, changes to drainage pattern and thereby ground water, interference with wild life movement, loss of productive agricultural lands, resettlement of people, disruption of local economic activities, demographic changes and accelerated urbanization. Highway development and operation therefore, be planned with careful consideration of the

environmental impact. To minimize these adverse effects that may be created by the highway development projects, the techniques of Environmental Impact Assessment (EIA) become necessary.

11.1.2 Scope of Work

Environmental assessment is a detailed process, which starts from the conception of the project and continues till the operation phases. The steps for environmental assessment are, therefore, different in different phases. The first steps for environmental assessment are known as scoping and screening. It is a preliminary Environmental Impact Assessment study for identifying major environmental issues and their broad mitigation measures. The findings of preliminary study guide to undertake more focused Environmental Impact Assessment Study.

The basic aim of the present study is to assess the magnitude of actual and potential environmental quality concerns due to conversion of the existing 2 lane National Highway into four lanes with paved shoulders. This is also to ensure that the environmental considerations are given due weight-age, in the design of proposed highway improvements being studied. Environmental Screening of the study area has the following major objectives:

- To generate baseline data for different environmental consequents including Ambient Air Quality, Noise level, Water Quality (surface & ground) and Soil Quality etc of the proposed project areas.
- To classify the type of environmental impacts on local environment.
- To recognize the potential environmental concerns.
- To delineate the major environmental issues and identify the potential hotspots, which requires further study i.e. scope for Environmental Impact Assessment (EIA).
- To determine the magnitude of potential impacts and ensure that environmental considerations are given due weight-age while selecting and designing proposed highway improvements.
- Design environmental measures to minimize negative impact of the project and maximize project positive impact on environment.

11.1.3 Study Area

The total length of the existing project road under consideration is 47.572 km. The project road starts from km 50+925 end at km 3+720 section of National highway 927D from Kalavad to Jamnagar in the state of Gujarat. The Key Map depicting the project road is presented previously in **Chapter-1 Figure 1.1**.

The areas of direct influence will be confined in a linear fashion along the corridor where the construction activities take place. The road is proposed to be retrofitted into four lanes with

paved shoulders. The existing ROW is varying from 24m to 30m. However, for various other environmental components, which are likely to have a broader area of influence, a distance of 10 km on either side of the road (as per the MOEF Notification of Environmental Impact Assessment, Government of India, 2006 and its amendment dated 1st December 2009) has been used to define the indirect area of Influence. Thus, the term project influence area referred in this chapter therefore, covers both direct and indirect area of influence. The Environmental Screening Report is based on field surveys and investigations made during site visit, and includes information depicting the existing environmental characteristics as well as an assessment of potential impact on the physical and natural environment of the area.

11.2 PROJECT ROAD

The existing road alignment passes through Jamnagar district of the Gujarat. The design length of project highway is 47.572 km. The areas of direct influence will be confined in a linear fashion along the corridor, where the construction activities take place. The road is proposed to be retrofitted into four lanes with paved shoulders. The existing ROW is varying from 24 m to 30 m.

By reconnaissance survey, it is found that existing carriageway width, in 92.21% of the Highway is of Intermediate lane i.e. 6m to 6.5 m. Remaining 7.79% of the highway is of 4-lane carriageway with divider i.e. 14.0 m. The stretch wise carriageway width along the project stretch is given in **Table 11.1 below**.

Table 11.1: Carriageway Width

S. No.	Existing Location (Km)		Length (Km)	Carriageway width (m)	Remarks
	From	To			
1	50+925	48+800	2.125	6 m to 6.5 m	-
2	48+800	45+200	3.600	14 m	Kalavad Town
3	45+200	3+720	41.480	6 m to 6.5 m	-

11.3 INVENTORY OF ENVIRONMENTAL FEATURES

Secondary Data

Secondary information on various environmental components such as physiographic, soil, geology, drainage, forest, ambient air quality, land-use, demography etc. were collected from various published sources to examine the baseline status of the environmental features in the project influence area.

In addition to the secondary data collected and the inventory information obtained, discussions with the stakeholders including the local people and government officials were held so as to provide a realistic assessment of any significant/ specific socio-environmental

concerns due to proposed project. These discussions helped in incorporating the views of the stakeholders.

11.4 PRELIMINARY ENVIRONMENTAL ASSESSMENT

The baseline environmental status of the project influence area is based on the field survey within proposed ROW and within the Corridor of Influence (COI). It will help in assessing the magnitude of potential impacts both beneficial as well as adverse due to the proposed project activities on the environment. The Environmental Impact Assessment (EIA) is aimed at determining the environmental impacts due to the construction and operation of the 2 laning of existing SH-26 on the study corridor encompassing areas falling within 10 km on either side of the project roads. The major environmental disciplines in this study would include topography and land use, soil & agriculture, geology & Seismicity, hydrology, climate and meteorology, air quality, water quality, noise level, terrestrial & aquatic ecology and sensitive receptors. In order to meet the broad aims and objectives of the study as discussed, a rational methodology and approach have been adopted.

11.5 STUDY METHODOLOGY

Environmental Screening process requires a thorough understanding of various environmental parameters and its effect on the project planning and implementation.

The screening process has under gone the following steps.

- Preparation for various surveys;
- Reconnaissance site visit;
- Preparation of all back ground data relating to the project roads that are to be screened;
- Preparation of base maps to plot the project roads accurately as far as possible;
- Identification of the valued ecosystem components (VEC) components that are important for the project;
- Devising or Preparation of formats for recording of these parameters;
- Identification of an environmental screening survey team;
- Training of the survey team to record the data in the survey formats;
- Actual ground surveys to collect or record the data in the relevant sheets;
- Analysis of the data collected by qualitative and quantitative techniques.

The Valued Environmental Components (VEC) are defined as social or bio physical component of an environmental which is of value (for any reason) in a project influenced area in the case of road project is a zone covering 10 km on both sides from the centre line of the project road. Some of the environmental components do have impacts to as far as 5-7 Kms. This could be water pollution or air pollution that can be carried out to far way distances. In yet some other cases this is even more as in the case of wildlife, debris disposal

and for material sources. Based on the studies, primary data on following Valued Environmental Components (VECs) shall be collected:

Physical Environment

- Disposal of debris/materials resources;
- Water resources (Surface and Ground water);
- Soil erosion;
- Air/water/Noise pollution.

Bio-Environment

- Number of trees within the ROW;
- Wildlife/nesting places/mod holes and other habitats;
- Forests;
- Reserved Forests (RFs);
- National parks and sanctuaries;
- Wetlands.

Socio-Economic Environment

- Drinking water sources;
- Schools/hospitals/college (declared silence zones);
- Cultural properties such as temples/shrines and other religious and Archaeological monuments and properties;
- Residential properties;
- Commercial properties;
- Tourism locations.

11.6 POLICY, LEGAL AND ADMINISTRATIVE FRAMEWORK

Review of the existing legislation, institutions and policies relevant to the Environmental Impact Assessment at the National and State levels has been done and clearance requirements for the project at various stages of the project have been identified.

Environmental Clearance

In terms of the provision of Ministry of Environment and Forests 2006 notification and its amendment dated 1st December 2009; this project will get classified as a category 'A' project of the said notification because of the following features of the road:

- The project road is more than 30 km in length of National Highway;

- The proposed by-passes and the widening along the existing alignment involve substantial acquisition of land Therefore the project will require prior environment clearance for execution.

The requirement of obtaining the clearances from authorities at the state level for the project is indicated in **Table 11.2**.

Table 11.2: Clearance Requirement for the Present Project

S. No.	Activity	Statutory Authority	Relevant Statute
1	Setting of hot mix plants, crushers and batching plants.	Gujarat State Pollution Control Board.	Air (Prevention and Control of Pollution) Act, 1981 and the Noise Pollution (Regulation and Control) Rules, 2000.
2	Establishment of workers camp, equipment and storage yards.	Gujarat State Pollution Control Board.	Environment Protection Act, 1986 and Manufacturing, Storage and Import of Hazardous Chemicals Rules, 1989.
3	Storage, handling and transport of hazardous materials.	Gujarat State Pollution Control Board.	Hazardous Waste (Management and handling) Rules, 1989 and Manufacturing, storage and Import of Hazardous chemical Rules, 1989.
4	Waste water discharge from labour camps.	Gujarat State Pollution Control Board.	Water (Prevention and Control of Pollution) Act, 1974.
5	Disposal of bituminous wastes.	Local Civil Body to identify solid waste disposal sites.	Hazardous Waste (Management and Handling) Rules, 1989.
6	Opening up new quarries.	Department of Commerce and Industries, Govt. of Gujarat.	Mines and Minerals (Regulation and development) Act, 1957 as amended in 1972.
7	Conservation of forests. Under the Act, no state government or other authority shall pass, except with the approval of the central government, any order (a) de-reserving	Department of Forest (Gujarat).	The Forest (Conservation) Act, 1980.

S. No.	Activity	Statutory Authority	Relevant Statute
	any reserved forest or part of it, (b) allowing any forest land for non-forest purpose, (d) allowing falling trees.		
8	Tree felling and removal from non-forest areas.	District Level Committee constituted by the State Govt. and chaired by the District Collector.	Procedural Guidelines developed by the Department of Environment, under the orders of the Hon'ble High Court; Tree removal will be guided as per state government rules.

11.7 DESCRIPTION OF ENVIRONMENT

11.7.1 Physical Resources

Right of Way and Terrain

As per the details obtained from the State PWD, Rajkot and Site road inventory, the Right of Way is 24m. The summary of existing ROW along the Project stretch is given in **Table 11.3**.

Table 11.3: Right of Way

S. No.	Section in Existing KM	Length (Km)	ROW (m)
1	Km 50+925 to Km 3+720	47.205	24

Topography

- Geographically, Gujarat has the following coordinates: 20° 6' N to 24° 42' N Gujarat is the westernmost state of India. It shares an international border with Pakistan. Indian states bordering Gujarat include Rajasthan to the north east, Madhya Pradesh to the east, Maharashtra to the south. The union territories of Diu, Daman, Dadra and Nagar Haveli to the south also share a border with Gujarat. Total area of Gujarat is 196,024 km².
- Jamnagar** is located on the southern coast of the Gulf of Kutch. The total area of the district is 14,125 sq. km. The land of Jamnagar district are mainly plain while the hills of Barda, Alech, Dales and the mountains of crop. Venue and abhpara are at the height of respectively 627 meters and 591 meters from the sea-level. Latitude of Jamnagar 21.42 degree to 22.57 degree North Longitude of Jamnagar 68.57 degree to 70.37 degree East.

- The geo-technical investigations and sub-surface explorations for the proposed Bridges along high embankments and any other location as necessary for proper Design of the works and conduct all relevant laboratory and field tests on soil and rock samples. The minimum scope of geo-technical investigations for bridge and structures will be as under:

S. No.	Description	Scope
1	Overall length = 6 – 30 m	One abutment location.
2	Overall length = 30–60 m	One abutment location and at least one intermediate location between abutments for structures having more than one span.
3	Overall length >30 m	Each abutment and each pier locations.

The deviation(s), if any, by the Consultants from the scheme presented above and will be submitted for IAHE approval

- Where a study of geo-technical reports and information available from adjacent crossings over the same waterway (existing highway and railway bridges) indicates that subsurface variability is such that boring at the suggested spacing will be insufficient to adequately define the conditions for design purposes; we will review and finalize the borehole locations in consultation with the IAHE.

Road near coastal area belong to Seismic zone III, and the road stretch farther from coast belong to Seismic zone II.

Climate & Meteorology

Climatically, a year in Gujarat can be divided into three seasons, the winter from November to February, the summer from March to May and monsoon season from June to September, with October being the intervening month. There is a great diversity in the climatic conditions across the state of Gujarat with different parts having markedly disparate climatic conditions. The places that lie near the coasts are humid whereas the ones lying in the interiors experience a completely different climatic condition. The Rann of Kutch region suffers an extreme climate where the summers are extremely hot while the winters are too cold. On the other hand, the coastal regions and the eastern belt of Gujarat experience a mild and pleasant climatic condition with moderate rainfall during the monsoons. Continue reading to learn more about the overall climatic condition and the geographical location of Gujarat. Gujarat state receives annual rainfall of 828 mm in 35 rainy days with coefficient of variation of 50 %.

Land use Pattern

Land use pattern along the project corridor is mainly agricultural land and built-up. Barren land and forest area are in very few stretches along the project road. Land use pattern in Gujarat State is given in **Table 11.4 below**.

Table 11.4: Land use Pattern along the Road Corridor

S. No.	Location	Land Use	Remarks
1	Km 1 to Km 6	Agriculture Land	Both Side
2	Km 6 to Km 6.2	Water Body	Both Side
3	Km 6.2 to Km 9	Residential	Both Side
4	Km 9 to Km 10	Mix use	Both Side
5	Km 10 to Km 12	Agriculture land	Both Side
6	Km 12- Km 13	Subeda river	Both Side
7	Km 13 to Km 16	Reserve Forest	RHS Side
8	Km 20 to Km 22.5	Reserve Forest	Both Side
9	Km 22.5 to Km 25	Mix land use	Both Side
10	Km 25 to Km 27	Agriculture land	Both Side
11	Km 27 to Km 31	Mix land use	Both Side
12	Km 31 to Km 32	Reserve Forest	LHS Side
13	Km 32 to Km 34	Agriculture land	Both Side
14	Km 34 to Km 36	By Pass mix land use	Both Side
15	Km 36 to Km 38.5	Agriculture land	Both Side
16	Km 38.5 to Km 39	Mix land use	Both Side
17	Km 39 to Km 45	Agriculture land	Both Side
18	Km 45 to Km 46	Agriculture land (Kalavad)	Both Side
19	Km 46 to Km 47	Mix land use	Both Side
20	Km 47 to Km 49	Mix land use(Water Body)	Both Side
21	Km 49 to Km 52	Agriculture land	Both Side

Source: Consultant Reconnaissance Survey.

Water Resources

Water body along the road corridor is identified as only Vijarakhi Dam and some seasonal surface drains.

11.7.2 Ecological Resources

This section dealt with the biological resources and issue in the study area that described in subsequent sections.

Flora

The list of flora in the study area is assessed during reconnaissance and given below:

Table 11.5: List of Common Flora in Study area

S. No.	Botanical Name	Local Name	Family
1	Acacia leucophloea	Hermo	Mimoseae
2	Acacia nilotica	Baval	Mimoseae
3	Acacia planifrons	Chhatralo baval	Mimoseae
4	Aegle marmelos	Bili	Rutaceae
5	Dalbergia sissoo	Sissoo	Caesalpiniaceae
6	Delonix elata	Sandesaro	Caesalpiniaceae
7	Delonix regia	Gulmohar	Caesalpiniaceae
8	Diospyros melanoxylon	Timru	Ebenaceae
9	Emblica officinalis	Amla	Euphorbiaceae
10	Erythrina variegata	Panarv	Fabaceae
11	Eucalyptus hybrid	Nilgiri	Myrtaceae
12	Ficus benghalensis	Vadlo	Moraceae
13	Ficus racemosa	Umro	Moraceae
14	Ficus religiosa	Pipal	Moraceae
15	Garuga pinnata	Karpati	Burseraceae
16	Grewia tiliacifolia	Dhaman	Tiliaceae
17	Holoptelea integrifolia	Charal	Ulmaceae
18	Lannea coromandelica	Moledi	Anacardiaceae
19	Mangifera indica	Ambo	Anacardiaceae
20	Manilkara hexandra	Rayan	Sapotaceae
21	Melia azedarach	Bakan limdo	Meliaceae
22	Mellingtonia hortensis	Akash nim	Bignoniaceae
23	Mimusops elengi	Bakul or borsali	Sapotaceae
24	Mitragyna parvifolia	Kalam	Rubiaceae
25	Morinda tinctoria	Al or rangari	Rubiaceae
26	Pongamia pinnata	Karanj	Fabaceae
27	Prosopis juliflora	Gando baval	Mimoseae
28	Prosopis spicigera	Khijado	Mimoseae
29	Rhizophora conjugata	Karoda	Rhizophoraceae
30	Salvadora oleoides	Mithijar	Salvadoraceae
31	Salvadora persica	Kharijar	Salvadoraceae
32	Sapindus emarginatus	Aritha	Sapindaceae
33	Schleichera oleosa	Kusum ujan	Sapindaceae

S. No.	Botanical Name	Local Name	Family
34	Soymida febrifuga	Ron	Meliaceae
35	Sterculia urens	Kadayo	Sterculiaceae
36	Syzygium cumini	Jambudo	Myrtaceae

Important agriculture crops that are grown in the study area are listed as below:

Table 11.6: List of Agricultural Crops in Study area

S. No.	Scientific Name	Common Name
Rabi		
Cereals		
1	Triticum aestivum	Wheat
2	Hordeum vulgare	Barley
Pulses		
3	Phaseolus	Gram
4	Lens culinaris	Lentil
Oil Seeds		
5	Brassica juncea	Mustard
Vegetables		
6	Coriandrum anum	Coriander
7	Allium sativum	Garlic
8	Capsicum anum	Chilly
9	Solanum tuberosum	Potato
10	Daucus carata	Carrot
11	Pisum sativum	Pea
Kharif Cereal		
12	Oryza sativa	Rice
13	Zea mays	Maize
14	Sorghum vulgare	Jowar
15	Millet	Bajra
Pulses		
16	Cajanus cajan	Arhar
17	Phaseolus angularis	Urd
18	Phaseolus mungo	Moong
Oil seed		
19	Seasamum	Til

S. No.	Scientific Name	Common Name
20	Arachys hypogaeal	Groundnut
21	Glycine max	Soyabean
22	Riccinus communis	Castor
Others		
23	Saccharum officinarum	Sugarcane
24	Gossipium species.	Cotton
Vegetables		
25	Capsicum anum	Chilly
26	Zingiber officinale	Ginger
27	Piper nigrum	Pipper

Source: District Agriculture Office, Project District and Consultant Reconnaissance Survey

Fauna

The list of mobile fauna in the study area is listed in **Table 11.7** below.

Table 11.7: List of Fauna found in the study area

S. No.	Scientific Name	Common Name
Animals		
1	Axis axis	Chital
2	Boselaphus magocamelus	Nilgai (Blue bull)
3	Canis laureus	Jackal
4	Macaca Fascicularis	Monkey
5	Felis caracal schreber	Caracal
6	Funambulus pennati	Squirrel
7	Hemiechninas auritus	Long Eared Hedge Hog
8	Hystriis indica	Porcupine
9	Presbytis entellus	Common Langur
10	Sus scrofa	Wild Boar
11	Vulpes bengalensis	Common Fox
Birds		
12	Accipiter badius	The Shikara
13	Acridotheres ginginianus	Bank Myna
14	Acridotheres tristis	Common Myna
15	Aloedo atthis	Small Blue Kingfisher
16	Anas clypeatea	Shoveller Duck

S. No.	Scientific Name	Common Name
17	Anadea alba	Large Egret
18	Anhinga rufa	Darter
Reptiles		
19	Varanus salvator	Water Monitor
20	Calotes versicolor	Garden lizard

Source: State Forest Department, Project Districts and Consultant Reconnaissance

11.7.3 Trees along the Road

The trees along the road are counted and found that there are approximately 8000 Trees in Jamnagar Forest division in the Road Corridor. Trees along the road fall under Protected Forest area of 47.429 ha. Reserved forest in the project area is 5.451 ha. Therefore, Total Forest Area is 52.880 ha, for which Forest application has been submitted vide Proposal No. FP/GJ/ROAD/27083/2017.

It is found that girth size of majority of the trees is 30-90 cm. The common trees found along the road are Peepal, Neem, Babool, Jamun, Karanj, Shisham, Eucalyptus, Cactus, Bargad, etc.

11.8 SOCIO-CULTURAL ENVIRONMENT

It is understood that the work of widening /improvement to 2 – lane has to be carried for as possible within the existing Right of Way so as to minimize land acquisition and resettlement Problems. All provisions for services by the consultant are made to achieve this objective. The provisions for environmental safeguard as specified by the Asian Development Bank/World Bank or Ministry of Environment and forest will be followed.

Total population of **Gujarat** as per 2011 census is 60,439,692 of which male and female are 31,491,260 and 28,948,432 respectively. **Jamnagar** had population of 2,160,119 of which male and female were 1,114,192 and 1,045,927 respectively. **Table 11.8** show the demography of Project Influenced Area in 2011.

Table 11.8: Demography of Project Influenced Area in 2011

Section Dhoraji-Jamnagar	Project Area	Jamnagar	Gujarat
		67.500 km	102.800
Area km ²	13159	14,184	196,024
Population	2506856	2,160,119	6,04,39,692
Population density per sq. km.	217	152	308
Decadal Growth	15.7	13.44%	19.28 %
Male	1295440	1,114,192	3,14,91,260

Section Dhoraji-Jamnagar	Project Area	Jamnagar	Gujarat
		67.500 km	102.800
Female	1211417	1,045,927	2,89,48,432
Sex Ratio	942	939	919
Percentage of total population	4.5	3.57%	4.99%
Child sex Ratio (0-6)	895	904	890
Literacy Rate	74.0	73.65%	78.03%
Male Literacy	82.0	81.50%	85.75%
Female Literacy	65.5	65.33%	63.31%
Scheduled Caste Population (%)	8.0	8.13%	6.7
Scheduled Tribe Population (%)	0.5	0.55%	14.8%
Urban Population	49.5	44.95%	42.06%
Rural Population	50.5	55.05%	57.04%

Source: *Primary Census Abstract 2011*

11.9 PUBLIC CONSULTATION

The habitat/ local residents whose properties/ livelihood are at stake due to the proposed project activities may be termed as stakeholders.

During the site visit, public meetings with the villagers were conducted, about the project awareness. Public consultation meetings will be held at project/ tehsil headquarters' along project road. The main objective of the public consultation, are the promotion of public understanding and fruitful solutions of developmental problems. During the site visit, public meetings with the villagers were conducted, about the project awareness.

While finalizing the road alignment efforts have been made by adopting appropriate engineering designs, to minimize resettlement impacts. To minimize displacement and to reduce disruption of livelihoods, concentric widening in village sections, bypasses to avoid settlement and raised carriageways have been proposed.

Public consultations and field visits helped in getting better planning and designing inputs towards minimizing adverse environmental impacts.

Vulnerable groups will be identified and given appropriate assistance to substantially restore their pre project status or improve their living standards.

11.10 IMPACT OF ENVIRONMENTAL RESOURCES

11.10.1 Regulatory and Institutional Regime

All National Policies and guidelines applicable to highway sector, the MORTH specifications on the environmental management for contractors, cross sector policies that has applicability

in highway sector e.g. minimum wages Act 1948; child labour Act, 1986 labour Act, 1988 right to information Act 2005.

The MoEF has the overall responsibility to set policy and standards for the protection of environment along with the Central Pollution Control Board (CPCB). This includes air, noise and water quality standards and the requirements for the preparation of Environmental Impact Assessment (EIA) statements for developmental projects.

Environmental management in India took a serious turn after the enactment of Environmental Protection Act 1986, an umbrella act, by the Indian Parliament. A number of rules, regulations and notifications have been passed under the EPA, with the help of which the Government of India regulates the environmental state of the country. One of the important Notifications with respect to all developmental projects in India and subsequently new EIA Notification 2006 issued.

The Environment (Protection) Act, 1986

The Environment (Protection) Act, 1986 is widely regarded as a comprehensive or umbrella legislation for environment in its entirety. The responsibility for implementation of the provisions of the EPA has to a large extent been entrusted to the regulatory agencies created under the Air and Water Acts. Department of Environment (DoE) was created in 1981 in the Central Government to act as a nodal agency for environmental protection and development in a co-ordinate manner.

The Environmental Impact Assessment Notification 2006

MoEF has issued new environmental impact assessment Notification on 14th September 2006. All projects and activities are broadly categorized in to two categories - Category 'A' and Category 'B' based on the spatial extent of potential impacts and potential impacts on human health and natural and manmade resources. All projects or activities included as Category 'A' in the schedule shall require prior environmental clearance from the Central Government in the Ministry of Environment and Forests (MoEF) on the recommendations of an Expert Appraisal Committee (EAC) constituted by the Central Government for the purposes of this notification. All projects or activities included as Category 'B' in the Schedule will require prior environmental clearance from the State/Union territory environment impact assessment authority (SEIAA). The SEIAA will base its decision on the recommendations of a State or Union territory level Expert Appraisal Committee (SEAC) constituted for this purpose. In the absence of a duly constituted SEIAA or SEAC, a Category 'B' project shall be treated as a Category 'A' project.

The highway projects are included in item no: 7(f) of schedule with following condition.

Project Activity	A Category	B Category	General Condition
Highways	i) New National Highways	i) New State High ways	Any project or activity specified in Category "B" will be treated as

Project Activity	A Category	B Category	General Condition
	ii) Expansion of National High ways greater than 30 KM, involving additional right of way greater than 20m involving land acquisition and passing through more than one State	ii) Expansion of National/ State Highways greater than 30 km involving additional right of way greater than 20m involving land acquisition	Category A, if located in whole or in part within 10 km from the boundary of: i) Protected Areas notified under the Wild Life (Protection) Act-72, ii) Critically Polluted areas as notified by the Central Pollution Control Board from time to time, iii) Notified Eco-sensitive areas, iv) Inter-State boundaries & international boundaries.
Provision as per 22 nd August 2013 MoEF Notification.			
	i) New National Highways ii) Expansion of national highway greater than 100 km involving additional right of way or land acquisition greater than 40 m on existing alignments and 60 m on re-alignments or by-pass	Not Applicable	Not Applicable

The project is 47.572 km long Kalavad-Jamnagar section of NH-927D that does not involve additional right of way or land acquisition greater than 40 m. Therefore, this project will be exempted from the EIA 2006 notification and it does not require environmental clearance as per the provision of 22nd August 2013 notification of MoEF.

The Forest (Conservation) Act, as amended in 1980

Forest (Conservation) Act, 1980 was enacted in 1980 to check irrational exploitation of forest and to maintain the ecological balance. This legislation is its endorsement of Government's will to protect the rich bio-diversity of our forest and wildlife, which is not only the natural heritage of our country, but also the base of our socio-economic progress and the repository of yet unknown panaceas of the future. The Act also translated into legal term the fact that forests in India are not to be regarded as sources of State revenue, but rather as community resources, sub serving the needs of hundreds of millions of rural people and tribal; and the principal duty of the forest Administration was no longer exploitation of forest wealth, as in colonial times, but conservation of bio diversity and green-cover.

Under this act no forest land can be used for non forestry purpose without the prior approval of Central Government. Therefore all proposals of diversion of such areas to any non-forest purpose can only be permitted by the Central Government. The Act pertains to the cases of diversion of forest land and felling of roadside plantation. Depending on the size of the tract to be cleared, clearances are applied for at the following governmental levels.

(a) Applicability of the Forest (Conservation) Act to the Roadside Strip Plantations

In 1986, when MOEF enacted the Environment Protection Act, the entire linear stretches of roadside plantations along the State Highways were declared as protected forest. Although the land is under the control of the PWD, due to its protected status, clearance is required to cut roadside trees. Applicability of the provisions of the Forest (Conservation) Act, 1980 to the linear (road or canal side) plantations was modified by a notification from the GoI - MoEF, dated 18 February 1998. The new notification recognized that the spirit behind the Forest (Conservation) Act was conservation of natural forests, and not strips plantations. In the case of the “notified to be protected” roadside plantations, the clearance now may be given by the concerned Regional Offices of the MOEF, irrespective of the area of plantation lost. While issuing the approval, in place of normal provision for compensatory afforestation, the Regional Offices will stipulate a condition that for every tree cut at least two trees should be planted. If the concerned Regional Office does not accord the clearance within 30 days of the receipt of fully completed application, the proponent agency may proceed with the widening/expansion under intimation to the State Forest Department, and the MoEF, Government of India.

(b) Forest land

Restrictions and clearance procedures proposed in the Forest (Conservation) Act apply wholly to the natural forest areas, even in case the protected/ designated forest area does not have any vegetation cover.

The Wildlife (Protection) Act, 1972

The Wildlife Protection Act has allowed the Government to establish a number of National Parks and Sanctuaries over the past 25 years, to protect and conserve the flora and fauna of the State.

The Water (Prevention & Control of Pollution) Act 1974 amended in 1988

The Water (Prevention and Control of Pollution) Act, 1974 resulted in the establishment of the Central and State Pollution Control Boards whose responsibilities include managing water quality and effluent standards, monitoring water quality, prosecuting offenders and issuing licenses for construction and operation of certain facilities.

The Air (Prevention & Control of Pollution) Act 1981 as amended in 1987

In the state of Maharashtra, State Pollution Control Board is empowered to set air quality standards and monitor and prosecute offenders under the Air (Prevention and Control of Pollution) Act, 1981. The responsibility for monitoring vehicular air and noise pollution lies

with the State Transport Authority (STA), not with the PCB. For water pollution and erosion, there is no institutional set-up for the road sector. The Government of India (GOI) standards for the discharge of pollutants to the environment (Water and Noise standards) are listed under the Environmental Protection Act. These standards apply mainly to the control of industrial pollution, with some applying to road construction projects.

The Noise Pollution (Regulation and Control) Rules, 2000

The Union Government has laid down statutory norms to regulate and control noise levels to prevent their adverse effects on human health and the psychological well being of the people. The rules titled Noise Pollution (Regulation and Control) Rules, 2000 have come into force at February 14, 2000. Under the new regulation, different areas and zones are to be identified as industrial, commercial, and residential or silence areas and anyone exceeding the specified noise level would be liable for action. In industrial areas, the noise level limit during the day time (6 am to 10 pm) is 75 decibels and during night (10 pm to 6 am) 70 decibels. Similarly, for commercial areas day time limit is 65 decibels and night limit is 55 decibels. In the case of residential areas, the limits are respectively 55 and 45 decibels and for the silence zones, 50 and 40 decibels.

The Motor Vehicles Act 1988

In 1988, amendment of the Indian Motor Vehicle Act empowered the State Transport Authority to enforce standards for vehicular pollution prevention and control. The authority also checks emission standards of registered vehicles, collects road taxes, and issues licenses. In August 1997, the “Pollution under Control” (PUC) programme was launched in an attempt to crackdown on the amount of vehicular emissions in the state.

Movement of Hazardous Chemicals

Movement of hazardous chemicals by road is governed by the Central Motor Vehicle Rules, 1989 (rules 129 through 137). Besides regulations and precautions to be taken while transporting such goods, the rules stipulate availability of a Transport Emergency (TREM) Card with the driver of the carrier which will provide information on hazardous nature of the chemical carried and also precautions required to handle emergencies such as spillage and fire.

Fly Ash Notification

MOEF has issued notification dated 14th September 1999 & subsequent amendment dated 27th August 2003 regarding the fly ash utilization. As per the notification, various construction activities including road construction within 100 km of coal based thermal power plant are to be undertaken by utilizing fly ash generated in thermal power plant. All agencies undertaking road construction activities have to make provision in their tender document for the same. Recently, MOEF has issued draft notification dated 3rd April 2007 for replacing the earlier fly ash notification which has following provision for utilization of fly ash in highway & fly over projects:

Use of fly ash in construction activities

No person or agency engaged in road construction may use borrow material excavated from the 'Right of Way' of the road for the construction of road embankments. All construction of road embankment will use fly ash or municipal inserts, unless:

- The cost of fly ash or municipal inserts delivered at the construction site is more than 25% higher than the equivalent quantity of soil extracted from other than the ROW for embankment use, in which case such soil may be used for the road embankment;
- A designated technical authority of the IRC certifies that the use of fly ash or municipal inserts at the location for the intended purpose is technically infeasible;
- For the top and side covers, soil, other than soil extracted from the ROW may be used, not with tending (a) above.

There is a Sikka Thermal Power Plant at a distance of 27 km from Junagarh. Therefore, the fly ash of the same is to be used during road construction.

Responsibility of agencies

All agencies undertaking construction of roads or fly over bridges including Department of Road Transport & highways, NHAI, CPWD, state public work departments and other state government agencies shall make appropriate provisions in their tender documents, schedules or approved material and rates, as well as technical documents, including those relating to soil borrow area or pit.

Ministries responsible for the environmental management in India are listed as below:

- Ministry of Environment and Forests (MOEF);
- Central Pollution Control Board (CPCB);
- State Pollution Control Board (SPCB);
- Department of environment and ecology in different states;
- The roles of other institutions like local bodies (Panchayats, Municipalities) are not yet well defined.

11.10.2 Environmental Acts and implications/application in the project context

- Indian Road Congress IRC 104: 1998;
- World Bank source book on environmental assessment (1995);
- World Bank operational policy 4.01 (1999);
- World Bank technical document.

11.10.3 Environmental categorization

The project can be undertaken as per the Environmental Notification of 1st December 2009, after taking Prior Environmental Clearance from the concerned regulatory authority, in the Ministry of Environment and Forests for matters falling under Category 'A' in the Schedule and at State level the State Environment Impact Assessment Authority (SEIAA) for matters falling under Category 'B' in the Schedule, before any construction work, or preparation of land by the project management except for securing the land, is started on the project or activity.

- The NOC/ Certificate to erect & operate for sitting labour camps, crusher plant, hot mix plant, construction machinery will be required from the State/ Central Pollution Control Board;
- The permission to be taken from Central Ground Water Board/Irrigation Department for the extraction of ground water/river water for construction purpose;
- The permission for the cutting road side tree which is felled due to widening and strengthening is taken prior to start the project from concerned Forest Department;
- Forest Clearance from concerned forest department for the diversion of forest land under the Forest Conservation Act, 1980;
- As per Ministry of Environment and Forest EIA Notification 14th September 2006, under 7 (f) the Environmental Clearance is required for Expansion of National/State Highways greater than 30 km, involving additional right of way greater than 20m involving land acquisition and passing through more than one state are required to take environmental clearance. This provision is amended via *latest MoEF notification (22nd August 2013) that state "expansion of national highway greater than 100 km involving additional right of way or land acquisition greater than 40 m on existing alignments and 60 m on re-alignments or by-pass" require prior environmental clearance.*

This project does not require additional Right of Way or land acquisition greater than 40 m. Thus, in the light of latest MoEF notification dated 22nd August 2013, this project does not require prior clearance.

The classification of the project for environmental assessment as per World Bank guideline is as under:

Category A : Proposed project is classified as Category A if it is likely to have significant adverse environmental impacts that are sensitive, diverse, or unprecedented. These impacts may affect an area broader than the sites or facilities subject to physical works.

Category B : Project is classified as Category B, if its potential adverse environmental impacts on human populations or environmentally important areas-

including wetlands, forests, grasslands, and other natural habitats-are less adverse than those of Category A projects. These impacts are site-specific; few if any of them are irreversible; and in most cases mitigatory measures can be designed more readily than for Category A projects.

Category C : Project is classified as Category C if it is likely to have minimal or no adverse environmental impacts. Beyond screening, no further EA action is required for a Category C project.

The proposed project road falls in **Category ‘B’** as per World Bank guideline, for which a environmental impact assessment study is required to design the mitigation measures to offset the adverse impact of the project on environment.

11.11 ENVIRONMENTAL IMPACT ASSESSMENT

The project will have following impacts on the environment:

- The Quarrying operations will generate high levels of particulate matter (PM₁₀ & PM_{2.5}) and to a very limited extent NO_x and CO due to fuel oil combustion. PM₁₀ & PM_{2.5} is the main cause of lung diseases and other respiratory disorders amongst the workers and nearby habitation. Transportation of material from quarry to crusher house by dumpers and hydraulic operated trucks/ tippers will also contribute to dust emissions to some extent.
- The Quarrying operation will generate a depression in the land which will disturb the land use and can affect the drainage of the area.
- Exposure of high level air pollution to adjoining inhabitants due to construction machinery and vehicle during construction stage and due to increased traffic during operation phase of the project;
- Exposure of high level of noise pollution to adjoining inhabitants due to construction machinery and vehicle during construction stage and due to increased traffic during operation phase of the project;
- Water pollution of water body along the stretch, if proper measures are not adopted;
- Solid and hazardous waste generation during construction and operation phase that need to be handled as per the applicable rules;
- Health and hygiene of the construction worker family at labor camps, if proper measures are not adopted;
- Rain water and storm water loss if proper measures are not adopted;
- Loss of livelihood, income and employment of the PAPs, if R&R plan is not designed and implemented properly;
- Loss of green vegetation of the area due to tree cutting;

11.12 ENVIRONMENTAL MANAGEMENT PLAN

The environmental management measures shall be implemented during the various stages of the project via: Pre-construction stage, Construction Stage and Operational Stage. The Environmental Management Plan (EMP) consists of a set of mitigation, monitoring and institutional measures to be taken during the design, construction and operational phases of the project to eliminate adverse environmental impacts, to offset them, or to reduce them to acceptable levels. The main aim of the Environmental Management Plan is to ensure that the various adverse impacts are mitigated and the positive impacts are enhanced. The environmental management plan is as described below.

11.12.1 Pre-Construction Stage

Pre-construction Activities by PIU/ Independent Consultant

Prior to the contractor mobilization, the PIU will ensure that an encumbrance free Corridor of Impact is handed over to enable the start of construction. Clearance involves the following activities:

- Removal and felling of trees is very minimal;
- Relocation of common property resources and community assets like telephone poles, electric poles and hand pumps will be impacted;
- Formal arrangements for maintenance of enhancement sites. This includes plantation of trees and barricades along the road;
- Modification (if any), of the contract documents by the Engineer of the Independent Consultant.

Pre-construction Activities by Contractor

- Pre-construction stage involves mobilization of the contractor and the activities undertaken by the contractor pertaining to the planning of logistics and site preparation necessary for commencing construction activities. The activities include;
- Joint field verification of EMP by the Environment Specialist of the Independent Consultant and Contractor;
- Identification and selection of material sources (quarry and borrow material, water, sand etc);
- Procurement of construction equipment / machinery such as crushers, hot mix plants, batching plants and other construction equipment and machinery;
- Selection, design and layout of construction areas, hot mix and batching plants, labour camps etc.
- Apply for and obtain all the necessary clearances/ NOC, s/ consents from the agencies concerned;

- Planning traffic diversions and detours including arrangements for temporary land acquisition.

11.12.2 Construction Stage

Construction activities by the Contractor

Construction stage is the most crucial stage in terms of activities that require careful management to avoid environmental impacts. There are several other environmental issues that have been addressed as part of good engineering practices, the costs for which have been accounted for in the Engineering Costs. They include providing roadside drainage, provision of cross drainage structures etc.

Construction activities by the PIU/ Supervision Consultants

The PIU/Independent Consultant shall be involved in the smooth execution of the project and assisting the contractor during this phase. Their work shall include but not limited to:

- Monitoring and guiding the contractor on adopting good environmental and engineering practices;
- Arrangement of plantation through the Forest Department;
- Arranging training to the contractor and other stakeholders according to the needs arising;
- Making changes in the design if need so arises.

11.12.3 Operation Stage

The operational stage involves the following activities by PIU:

- Monitoring of environmental conditions through approved monitoring agency;
- Monitoring of operational performance of the various mitigation/ enhancement measures carried out.

11.12.4 Environment Budget

The details of Environmental Budget is given in **Table 11.9**.

Table 11.9: Environmental Budget

Component	Stage	Item	Unit	Unit Cost (Rs.)	Quantity	Total Cost (INR)
Trees	Pre - Construction	Felling of Trees	Nos.	100	Girth size (>300 mm) =856	85600
			Nos.	100	Girth Size (300 mm-600 mm) =3986	398600
			Nos.	500	Girth Size (600 mm – 900 mm) =1758	879000
			Nos.	1000	Girth Size (900 mm- 1500 mm) = 993	993000
			Nos.	3000	Girth size (>1500 mm) =397	1191000
		Compensatory Afforestation	No.	800	16000	12800000
	Construction	Land for Compensatory Afforestation (Per Tree Avg. area covered 9m²)	Lac/ Hectare	600000	14.4 Ha.	8640000
				Total Afforestation Cost		2,49,87,200
(A) Mitigation cost						
Air	Construction	Dust Management with sprinkling of water, covers for vehicle transporting construction material for about 48 month	per month per km	4000	48	1,92,000
Water	Construction	Oil interceptor at parking of construction vehicle and storage of diesel and lubricants 2 Nos Silt Fencing	Each	1,00,000	1	1,00,000
Sub-Total: A-Mitigation cost						2,92,000

Component	Stage	Item	Unit	Unit Cost (Rs.)	Quantity	Total Cost (INR)
(B) Monitoring costs						
Air Quality	Construction	Monitoring along the road by contractor (including local Transport)	No. of Samples	5000	At 3 locations, thrice in a year for a period of 4 years and for 24 hours in 3 shifts (Total $3 \times 36 = 108$)	540000
		Monitoring at Hot mix plant and batch plant (ambient air quality)	No. of Samples	5000	At 2 locations thrice in a year for 4 years, for 24 hours in 3 shifts (Total $2 \times 36 = 72$ Samples)	3,60,000
		Monitoring at Hot mix plant and batch plant (Stack Monitoring)	No. of Samples	4000	At 2 locations thrice in a year for a period 4 years (Total $2 \times 3 \times 4 \times 3 = 72$ Samples)	2,88,000
	Operation	Monitoring along the road at locations where monitoring was done during constructions (including local Transport)	No. of Samples	5000	At 3 locations, thrice in a year for a period of one years (Total $3 \times 3 \times 1 \times 3 = 27$ Samples)	1,35,000
Water Quality	Construction	Drinking water quality monitoring of labor camps/ works site	No. of Samples	5000	At 3 locations, Thrice in a year for 4 years (Total $3 \times 3 \times 4 = 36$ samples)	1,80,000
	Operation	Monitoring along the road at locations where monitoring was done during constructions	No. of Samples	5000	At 3 locations thrice in a year for 1 year (Total $3 \times 3 \times 1 = 9$ samples)	45,000
Noise Quality	Construction	Monitoring along the Hot mix plant, Batch plant & other sensitive locations	No. of Samples	1000	At 3 locations, Thrice in a year for 4 years for 24 hours in day time & night time (Total $3 \times 3 \times 4 = 36$ Samples)	36,000
	Operation	Monitoring along the road at locations where monitoring was done during	No, of Samples	1000	At 3 locations, Thrice in a year for 1 years (Total $3 \times 3 \times 1 = 9$ Samples)	9,000

Component	Stage	Item	Unit	Unit Cost (Rs.)	Quantity	Total Cost (INR)
		constructions				
Soil Quality	Construction	Monitoring along hot mix plant and batch plant and some other location	No of Samples	3000	At 2 locations, thrice in a year for 4 years (Total 2x3x4 = 24)	72,000
	Operation	Monitoring along the road at locations where monitoring was done during constructions	No. of Samples	3000	At 3 locations thrice in a year for 1years (Total 3x3x1 = 9 samples)	27,000
Sub-Total B- Monitoring Costs						16,92,000
Sub-Total C-Training & Other Costs						
Training & Mobilization costs		As per modules developed	L.S.			10,00,000
Construction and operation						
Sub-Total C: Training & Mobilization Costs						10,00,000
SUMMARY						
Sub Total A: Mitigation						2,92,000
Sub Total B: Monitoring Cost						16,92,000
Sub Total C: Training & Mobilization Costs						10,00,000
Total Afforestation Cost						2,49,87,200
TOTAL						2,79,71,200
Contingency @ 5%						13,98,560
TOTAL EMP BUDGETED COSTS						2,93,69,760
EMP cost is approx 2.94 Crore						

11.13 ENVIRONMENTAL MONITORING PROGRAMME

The purpose of the monitoring programme is to ensure that the envisaged purpose of the project is achieved and results in desired benefits to the target population. To ensure the effective implementation of the EMP, it is essential that an effective monitoring program be designed and carried out. The periodic monitoring programme will ensure checking whether the concentration of pollutants at the project site within the permissible limits prescribed by CPCB and in compliance with regulatory requirements. In addition, monitoring would enable early detection of rise in levels of critical pollutants and facilitate timely corrective actions to control pollution. The details of Environmental Monitoring Programme envisaged for the project is presented in **Table 11.10**.

Table 11.10: Environmental Monitoring Programme

Parameters	Locations	Duration	Frequency
Air Quality: SPM, RSPM, NO _x , SO ₂ and CO	Construction Area and Crushing or Hot Mix Plant sites	24 hours continuous sampling	Twice in a week for three season
Noise Level: Leq (day) & Leq (night)	Construction Area and Crushing or Hot Mix Plant sites	24 hours continuous sampling	Once in week for three season
Water Quality: Physical, Biological & Chemical parameters	One surface water sample & six ground water samples	Close to construction area	Twice in a year (pre monsoon and post monsoon)
Soil Quality: For lead and Oil & Grease.	Oil storage yard and Machinery workshop site	Grab sampling	Once in a year (non monsoon season)
Maintenance of plantation	At selected locations	Throughout the year	Regularly throughout the year



CHAPTER - 12

SOCIAL ASSESSMENT AND PRELIMINARY LAND ACQUISITION/ RESETTLEMENT PLAN

CHAPTER - 12

SOCIAL ASSESSMENT AND PRELIMINARY LAND ACQUISITION/ RESETTLEMENT PLAN

12.1 INTRODUCTION

Road projects are generally undertaken to improve the economic and social welfare of the society to whom it provides good connectivity. Augmented road capacity and improved pavements can reduce travel time and costs for both freight and passengers. Benefits include increased access to markets, Jobs, education and health services. For all the positive aspects of road projects, they may also bring significant negative impacts on nearby communities and the natural environment. Roads bring people and people bring development. Roads are agents of change, which can bring both benefits and damage to the existing balance between the people and their environment.

Social Impact Assessment (SIA) is a process of analysing, predicting and evaluating the future Inputs of development project on the well-being of people, and their businesses, institutions and communities. Its goal is to protect and enhance the quality of life by applying the mitigate measures.

The Indian Academy of Highway Engineers (IAHE) has been entrusted with the assignment of Project Management Consultancy Phase I including preparation of Detailed Project Report of selected stretches/ corridors of National Highways for Two/ Four laning with paved shoulder configuration in the States of Maharashtra, Gujarat, Chhattisgarh, Rajasthan and Karnataka. Under this phase, Government of India felt the necessity of upgradation of road section between Dhoraji-Jamkandorna-Kalavad-Jamnagar of a proposed length 105.687 km section of NH-927D.

The project influence area is considered to be the district through which the Corridors road is passing. National Highway -927D (NH 927D) lies in western India. Earlier it was SH-26 and recently converted into NH-927D. NH-927D connects Dhoraji in Rajkot district with Jamnagar in Gujarat. The present SH-26 notified into NH-927D vide S.O. No. 1522(E) dated 13.06.2014. The project road starts from km 50+925 at Kalavad and end at km 3+720 at Jamnagar section of National highway 927-D. The Proposed length of the project highway (Package-2) is 47.572 km. The Key Map depicting the project road is presented in **Figure 1.1 in Chapter-1**.

The initial Social survey for the project road NH-927D has been conducted to determine the magnitude of present and future impact due to widening and strengthening of the existing road and to ensure that social considerations have been given adequate weight-age in the selection and design of proposed highway improvements. Basic idea is to minimize adverse social impacts with best possible engineering solutions at the optimal cost.

The social Assessment process generally begins with screening at the time of project identification where steps are taken from the beginning and plans/ designs/ alignments are finalized in such a way that to the extent possible adverse impacts are avoided at the designing stage itself and make these roads people friendly. These steps are:

- Predicts the nature and size of potential negative and positive effects on individuals, businesses and communities;
- Develops and implements appropriate recommendations and impact management measures to avoid or decrease potential negative socio-economic impacts and enhance positive impacts;
- Identifies net social and economic impacts occurring after mitigation measures are applied, including roadway routing, design and operating conditions; and
- Helps resolve public issues by working with the community to address the potential impacts;
- Avoiding the adverse social impact at the designing stage especially while finalizing the alignments.

The overall objective of conducting social screening is to provide input of social concerns to be dovetailed in highway design and for complete co-ordination between the engineering, environmental and social teams during the entire design process.

12.2 METHODOLOGY

For minimum land acquisition, resettlement and adverse impacts on community in the project area a 100% census, and 25% socio-economic survey was conducted .Steps have already been made to confine the project area in the government land and in available right of way (ROW) where feasible. This has been done with proper consultation with the local people and affected communities. Their suggestions have been incorporated, in the design, wherever technically feasible. There will be some unavoidable land acquisition for which adequate compensation shall be provided. For the proposed work the following specific measures are taken to minimize resettlement in this project road.

- Selection of sites and its various components in the government land; and
- Adequate engineering design to avoid and minimize displacement and resettlement.

Both primary and secondary data are required for establishing the extent of impact, which need to be collected by administering the questionnaire for collecting information on structures, properties, land and type of ownership and social groups etc. with the help of enumerators/ investigators and by collecting secondary data from different govt. and non govt. sources.

As per the details obtained from the State PWD, Jamnagar and Site road inventory, the Right of Way is 24m. The summary of existing ROW along the Project stretch is given in **Table 12.1**.

Table 12.1: Detail of Existing Right of Way (ROW)

S. No.	Section in Existing KM	Length (Km)	ROW (m)
1	Km 50+925 to Km 3+720	47.205	24

12.3 CENSUS AND SOCIO-ECONOMIC SURVEY RESULTS

Presently reconnaissance survey and local level public consultation has been conducted, on the basis of present alignment. Since the alignment is not yet finalized, anticipated impacts on the population adjoin the project is discussed below:

A brief analysis of the demographic and socio-economic profile of the project influenced district is provided in **Chapter-3**.

The project stretch passes through in two districts namely Jamnagar and Rajkot. The technically feasible project proposals are being proposed considering land requirement of 30m and 45m for bypass. As per the reconnaissance survey it is found that the traffic is generally more between Kalavad to Jamnagar as compared to Kalavad to Dhoraji. The social economic survey will be carried out on the basis of affected structures & other assets of proposed land corridor of project stretch.

The census inventory identified 51 structures are to be affected with 306 people in which identified 12 Residential Houses are affected, 11 structures are Commercial, 8 Bus stops, 1 Temple and 7 Wells, 11 Sump, 1 Tank in the project stretch.

The sex ratio among the project-affected population is slightly low. It is less than the state and national level figure. The average family size in the project area is 6.0 persons per family. The Sex ratio of the affected families shown below in **Table 12.2**.

Table 12.2: Sex Ratio of Affected Population

Section	Project Affected People	Male	Female	Sex Ratio (F:M) per thousand
Kalavad to Jamnagar	272	141	131	931

Source: Reconnaissance Survey by CEG, Jaipur.

The sex ratio among the project-affected population is slightly low. It is less than the state and national level figure. This indicates that there is a need on the part of the state government to intervene.

12.3.1 Indigenous People and other Social Vulnerabilities

This project is not going to affect significantly the Scheduled Tribe (ST) or IPs. However, efforts have been made to identify critical social issues such as indigenous/tribal people, gender impacts, use of child labor, the very poor (i.e., those below the poverty line), and HIV/AIDS and health associated with project impacts. This chapter examines the issues from social safeguard considerations to develop specific mitigation measures. Though there are no indigenous people to be affected directly by the project but these issues are being addressed in the resettlement plan in order to guide that mitigation measures will be taken and special attention will be paid to the vulnerable people if they are likely to be affected. An Indigenous People's Development Framework (IPDF) which will serve as a guideline to manage the IP issues if comes in the future.

12.3.2 Education Level of the Affected Persons

Since almost half of the project affected persons are either illiterate or have low education level, training programs for income restoration may be an important part of rehabilitation measures. **Table 12.3** shows the education level of the project affected people.

Table 12.3: Educational Level of the Project Affected People

Section	Illiterate	Primary	Middle	Higher Secondary	Graduate	Post Graduate
Kalavad to Jamnagar	4.1	10.1	15.3	23.7	25.2	21.6

Source: Reconnaissance Survey by CEG, Jaipur.

12.3.3 Occupational Background of Households

The workforce participation ratio of the project-affected people is about 98 % as shown in **Table 12.4**. Among the titleholder affected people, business & allied activities is the main livelihood. This accounts for 28 % of total workforce. About 19.5% are farming/agro related workers & vendors who constitute the other important occupation. 33% is working as daily wage labours, and 12.4% of the people are in service.

Table 12.4: Occupational Background of Household (Affected People) as % of Workforce

Section	Farming/Agro Related	Dairy/ Poultry	Trade/ Business	Daily Wage	Service	Others
Kalavad to Jamnagar	19.5	5.1	28	33	12.4	2

Source: Reconnaissance Survey by CEG, Jaipur.

Most of the small businesses are run in squatter structures and both labour and housework are low paid or unpaid jobs. According to the social and economic analysis of the project affected people, agriculture and small business together constitute the bulk of the total employment among the APs. Only few of the affected population are employed in the private or government service sector. Thus, the occupational pattern of the population is not diversified and efforts at income restoration would be directed at enhancing business opportunities of the displaced population.

12.3.4 Ownership Status of the Structures

Various types of structures were enumerated. For the affected titleholders, residential usage occupies the largest number of structures. About 23.5% of the total structures are residential in nature 21.6% of the structures is commercial and rest 54.9% are religious & common property. **Table 12.5** shows the loss of different category of structures.

Table 12.5: Loss of Different Category of Structures

Section	Residential	Commercial	Religious	Common Property/ Govt. Structures	Total
Kalavad to Jamnagar	12	11	1	27	51

Source: Reconnaissance Survey by CEG, Jaipur.

12.3.5 Rehabilitation Options

According to the census survey of the project-affected people, 92.5 % of the Families prefer cash compensation for their land as well as structures. **Table 12.6** presents options as suggested by the APs, which represents quite a contrast. It is seen that most titleholders are opting for cash in lieu of their land and livelihood loss. Very few people have opted for land or occupational training as compensation for losses. **Table 12.6** shows the family Rehabilitation options in percentage.

Table 12.6: Family Rehabilitation Options in Percentage

Section	Cash Compensation	Land for Land	Land & Cash	Occupational Training
Kalavad to Jamnagar	92.5	3.5	1.6	2.4

Source: Reconnaissance Survey by CEG, Jaipur.

12.3.6 Impacts on Utilities

In addition to the impact on the private properties along the highway and in the new alignment section, the project also has an impact on utilities that are used by the local community. The utilities mainly found are, structures, Petrol Pumps 1, and 1 Religious property.

12.4 MEASURES TO MINIMISE DISPLACEMENT

National policy recognizes that displacement results in “state-induced impoverishment”. It also recognizes that “no developmental project can be justified if a section of society is pauperized by it”. Displacement from one’s habitual residence and the loss of property without fair compensation can, in itself constitute a violation of human rights.

12.4.1 Public Consultation

To ensure peoples’ participation in the planning phase of this project and to treat public consultation and participation as a continuous two way process, the Census/ Survey team carried out preliminary consultation, through focus group discussions (FGDs) and meetings with the APs as well as the general public in the project area through individual interviews. The main objective of the public consultation are the promotion of public understanding and fruitful solutions of the problems arising due to developmental project, primarily in settlements with problems of traffic congestion, dense squatter settlement, road intersections. During the survey, intensive discussion and consultation meetings will be conducted with large number of APs in nearly every affected village wherein policy related issues; displacements and other related issues will be discussed. During reconnaissance survey for awareness in project area some public consultations is held. Sample photos given below in **Figure 12.1**.



**Information Dissemination in Modpar
district Jamnagar**



**Public Consultations in Jasapar in Rajkot
district**

Figure 12.1: Public Consultations

12.4.2 Improvement proposal and analysis

While finalizing the road alignment/ curve improvement/ bypasses efforts have been made by adopting appropriate engineering designs, to minimize resettlement impacts and safety consideration for road user. This project upgradation requirement is two lane paved shoulder considering traffic varies between 3000 PCU to 10766 PCU. The project stretch having major Habitat area at Kalavad where existing stretch partly four laned with deficient geometry. Three options were explored through bypasses and on existing alignment. Preferred option selected based on techno economical ground. Similarly, some stretch at Khandhera, Vijarkhi, Haripar are most geometrically deficient stretches and accident project areas due to geometry. It is required to improve geometry of the stretches by realigning for which land acquisition requirement will come. The project stretch mostly having submersible bridges at curve portion. To improve the geometry and replacing high level bridge in place of submersible realignment required to be done and land acquisition requirement will arise.

12.4.3 Entitlement Framework

Involuntary resettlement should be avoided, where feasible, or minimized, exploring all viable alternative project designs. Where it is not feasible to avoid resettlement, resettlement activities should be conceived and executed as sustainable development programs, providing sufficient investment resources to enable persons displaced by the project to share in project benefits. People unavoidably displaced should be compensated and assisted as per the resettlement plan/ framework prepared for the project, so that their economic and social future would be generally as favorable as it would have been in the absence of the project.

- ❖ Gender equality and equity would be ensured and adhered to;
- ❖ Affected Persons (APs) shall be fully involved in the selection of relocation sites, livelihood compensation and development options at the earliest opportunity. RPs should also be prepared in full consultation with AP, including disclosure of RP and project related information;
- ❖ Replacement land shall be an option for compensation in the case of loss of land; in the absence of replacement land, cash-for-land compensation on replacement value option will be made available the APs;
- ❖ Compensation for loss of land, structures, other assets and income will be based on full replacement cost and will be paid before physical displacement of AP;
- ❖ All compensation payments and related activities will be completed prior to the commencement of civil works;
- ❖ RP will be planned and implemented with full participation of local authorities;

- ❖ In the event of necessary relocation, APs shall be assisted to integrate into host communities;
- ❖ Common property resources and community/ public services will be provided to APs.

Resettlement will be planned as a development activity for the APs; all titleholders are entitled to receive compensation/assistance; however people moving in the project area after the cut-off date will not be entitled to any assistance. In case of land acquisition the date of notification for acquisition will be treated as cut-off date. For non-titleholders such as squatters and encroachers the date of census survey or a similar designated date declared by the executing agency will be considered as cut-off date; and

- 1) Replacement cost means the method of valuing assets to replace the loss at market value, or its nearest equivalent, plus any transaction costs such as administrative charges, taxes, registration, and titling costs;
- 2) While compensation is required prior to dispossession or displacement of affected people from their assets, the full resettlement plan implementation, which may require income rehabilitation measures, might be completed only over a longer period of time after civil works have begun. Affected people will be provided with certain resettlement entitlements, such as land and asset compensation and transfer allowances, prior to their displacement, dispossession, or restricted access.

12.5 PUBLIC CONSULTATION, PARTICIPATION AND DISCLOSURE OF INFORMATION

All relevant aspects of project planning and development were discussed with primary and secondary stakeholders, including directly affected people, Executing Agency, and other local administrative agencies and departments. The directly affected population was consulted to understand their concerns and receive their suggestions on the types of mitigation measures that should be considered to address them. At the field level, to ensure a comprehensive perspective on the project and its impacts, focus group discussions involved (i) head of village panchayats; (ii) village administrative officers; (iii) men; (iv) women; (v) farmers; (vi) business communities; (vii) concerned government departments; and (viii) vulnerable groups. Further, the consultations and discussions with the APs will continue throughout the implementation of the subproject. A local non-government organization (NGO) will assist the project implementation units (PIU) with it. The NGO's involved in the resettlement implementation activities will keep the title holder APs were informed about the impacts, compensation, and assistance proposed for them; and will facilitate in addressing any grievances.

Experience indicates that involuntary resettlement generally gives rise to severe problems for the affected population. These problems may be reduced if, as a part of RP implementation, people are properly informed and consulted about the project, about their situation and preferences, and are allowed to make meaningful choices. This serves to reduce the insecurity and opposition to the project which otherwise are likely to occur.

12.6 POLICY FRAMEWORK

The policy framework and entitlements for the Project are based on national laws: The Land Acquisition Act (LARR Act, amended in 2013), The National Rehabilitation and Resettlement Policy, 2007 (NRRP). The following section deals with these policies with a comparison and subsequently deals with the entitlements and eligibility for compensation and other resettlement entitlements.

12.6.1 Applicable Legal and Policy Framework

Applicable Acts and Policies relevant in the context of the project have been reviewed and their relevance to the project outlined in **Table 12.7** R&BD will ensure that project activities implemented are consistent with the following regulatory/legal framework.

Table 12.7: National and World Bank Policies Relevance & Applicability for the Project

S. No.	Act and Policies	Relevance to this Project	Applicability
1.	Land Acquisition Act, 2013	Land required for the project shall be acquired as per the provision of this Act.	Applicable to all project corridors.
2.	National Rehabilitation and Resettlement policy (NRRP), 2007	This policy provides for basic minimum requirements. The State Governments, other requiring bodies can also opt for greater benefit levels than those prescribed in this policy.	Applicable to all project corridors.
3.	Provisions of the Panchayats (Extension to the Scheduled Areas) Act, 1996	One of the important provisions of this act states “Gram Sabha or the Panchayats at the appropriate level shall be consulted before making the acquisition of land in the scheduled Areas for development projects and before re-setting or rehabilitating persons affected by such projects in the Scheduled Areas.	Applicable to Fifth Schedule Areas.

S. No.	Act and Policies	Relevance to this Project	Applicability
4.	The Scheduled Tribes and other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006	This law provides for recognition of forest rights to Scheduled Tribes in occupation of the forest land prior to 13.12.2005 and to other traditional forest dwellers who are in occupation of the forest land for at least 3 generations i.e. 75 years, up to maximum of 4 hectares. These rights are heritable but not alienable or transferable.	Applicable to project corridors, which have ST population in the project corridor.
5.	World Bank OP 4.12 Involuntary Resettlement	Cash compensation should be sufficient to replace the lost land and assets; eligibility of benefits include, the PAPs who have formal legal rights to land (including customary and traditional land rights recognized under law), the PAPs who don't have formal legal rights to the land they are occupying; particular attention to the needs of vulnerable groups; timely and relevant information to displaced persons, consulted on resettlement options, and offered opportunities to participate in planning, implementing, and monitoring resettlement; establishment of grievance mechanisms.	Applicable to all project corridors.
6.	The Right to Information Act, 2005	The Act provides for setting out the practical regime of right to information for citizens to secure access to information under the control of public authorities, in order to promote transparency and accountability in the working of every public authority.	Applicable to all project corridors

Source: Roads and Building Department Government of Gujarat

12.6.2 Land Acquisition, Rehabilitation and Resettlement, Act-2013 Amended 2014)

The LARR Act provides a framework for facilitating land acquisition in India. LAA enables the State Government to acquire private land for public purposes. LAA ensures that no person is deprived of land except under LAA and entitles APs to a hearing before acquisition. The Bill provides for land acquisition as well as rehabilitation and resettlement. It replaces the Land Acquisition Act, 1894 the main elements of LARR Act are:

- The Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement (Amendment) Ordinance, 2014 was promulgated on December 31, 2014. The Ordinance amends the Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2013 (LARR Act 2013);
- **Provisions of other laws in consonance with the LARR 2013:** The LARR Act 2013 exempted 13 laws (such as the National Highways Act, 1956 and the Railways Act, 1989) from its purview. However, the LARR Act 2013 required that the compensation, rehabilitation, and resettlement provisions of these 13 laws be brought in consonance with the LARR Act 2013, within a year of its enactment, through a notification. The Ordinance brings the compensation, rehabilitation, and resettlement provisions of these 13 laws in consonance with the LARR Act 2013;
- **Exemption of five categories of land use from certain provisions:** The Ordinance creates five special categories of land use: (i) defiance, (ii) rural infrastructure, (iii) affordable housing, (iv) Industrial corridors, and (v) infrastructure projects including Public Private Partnership (PPP) projects where the central government owns the land;
- The LARR Act 2013 requires that the consent of 80% of land owners is obtained for private projects and that the consent of 70% of land owners be obtained for PPP projects. The Ordinance exempts the five categories mentioned above from this provision of the Act;
- In addition, the Ordinance permits the government to exempt projects in these five categories from the following provisions, through a notification:
 - (i) The LARR Act 2013 requires that a Social Impact Assessment be conducted to identify affected families and calculate the social impact when land is acquired;
 - (ii) The LARR Act 2013 imposes certain restrictions on the acquisition of irrigated multi-cropped land and other agricultural land. For example, irrigated multi-cropped land cannot be acquired beyond a limit specified by the government.

- **Return of unutilized land:** The LARR Act 2013 required that if land acquired under it remained unutilized for five years, it was returned to the original owners or the land bank. The Ordinance states that the period after which unutilized land will need to be returned will be five years, or any period specified at the time of setting up the project, whichever is later;
- **Time period for retrospective application:** The LARR Act 2013 states that the Land Acquisition Act, 1894 will continue to apply in certain cases, where an award has been made under the 1894 Act. However, if such as award was made five year or more before the enactment of the LARR Act 2013, and the physical possession of land has not been taken or compensation has not been paid, the LARR Act 2013 will apply.

Salient Features of the Bill

- Consent of 80 percent of landowners required in case of land acquired by private companies and 70 percent for land acquired under Public Private Partnership (PPP) model for public purpose;
- Compensation up to four times the market value in rural areas and twice in urban areas;
- Mandatory Social Impact Analysis (SIA) to assess nature of public interest and estimation of socio-economic impact prior to acquisition;
- Land cannot be vacated until the entire compensation is awarded to the affected parties;
- Companies can lease the land instead of purchasing it;
- Private companies to provide for rehabilitation and resettlement if land acquired through private negotiations is more than 50 acres in urban areas and 100 acres in rural areas;
- Affected families include farm labour, tenants, sharecroppers and workers on the piece of land for three years prior to the acquisition;
- Compensation should be house, one time allowance and (either Rs 5 lakh or a job or inflation adjusted Rs 2,000 per month for 20 years) for the affected family;
- Compensation of four times the market value in rural areas and twice in urban areas will be given to affected families. The market value of the acquired land shall be based on the higher of Market value specified in the Indian Stamp Act, 1899 for the registration of sale deeds average of the top 50 percent of all the sale deeds in the similar type of land situated in the vicinity or the amount agreed upon as compensation for acquisition of land for private companies or PPPs.

The value of the assets (trees, plants, buildings etc.) attached to the land being acquired will be added to this amount. The Bill proposes that in cases where the ownership of an acquired land is sold to any person, without any development made, 40 percent of the profit made shall be shared among all the persons from whom the land was acquired **Table 12.8** shows the Rehabilitation and Resettlement package stipulated by the Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Bill 2013.

Table 12.8: Proposed R&R package in LARR 2013

Package component	Affected person	Detail
Determined market value of land	Land owners	a) Market value if specified in the Indian Stamp Act 1899 for the registration of sale deeds or agreement to sell where the land is situated at. b) Average sale price for similar type of land situated in nearest village or vicinity area. c) Consented amount of compensation as agreed upon in case of acquisition of land for private/ PPP companies. Whichever is higher: • Average sales price shall be determined taking into account sales deeds or agreements to sell for similar type of area in vicinity during immediately preceding three years. • Above average sale price will be determined by taking into account one half of the total number of sale deeds or agreements to sell in which highest price has been mentioned. • Any price paid as compensation under this Act in the district on an earlier occasion will not be considered as market value or average sale price. • Any price paid as per above which in opinion of Collector is not indicative of prevailing market price may be discounted for purposes of calculating market value. • Where market value cannot be determined if land is situated in area where land transactions are restricted or sales deeds/agreements to sell in similar area are not available or market value has not been specified as per a) above-State government concerned shall specify floor price based on price calculated in respect to similar land in adjoining areas.
Solatium	Rural	$x \times$ determined market value + value of assets attached to land, where x is 1 or 2 based on distance from urban area.
	Urban	Determined market value + value of assets attached to land.

Package component	Affected person	Detail	
R&R	Land owners	(A) Subsistence allowance	Rs 3000*12 month.
		(B-1) Annuity	Rs 2000*12 month*20 years, with indexation.
		(B-2) Employment	For 1 member per family.
		(B-3) One time	Rs 5 lac per family.
		(C) Transportation	Rs 50,000.
		(D) Constructed house	If house is lost, constructed house in urban area.
		(E) Land	1 acre if land acquired for irrigation project.
		(F) Land	20% of developed land reserved for land owner, if acquired for urbanization in place of compensation.
		(G) Appreciation benefit	40% of appreciated land value if undeveloped land sold within 5 years.
		(H) Others	Fishing rights, artisan grant, small trader grant etc.
	Livelihood losers	A, B, C, D, E above and additional resettlement allowance of Rs 50,000.	
	Scheduled tribes (ST)	Special provisions including preparation of development plan, land for land, etc.	
Infrastructural amenities	In case of resettlement	25 amenities including roads, drinking water, sanitation, individual electric connections, school, basic irrigation facilities, health centre etc.	

Note: Option to affected family from B-1, B-3.

Additional 12% per annum on market value from the date of SIA notification;

Stamp duty and registration fee to be paid by requiring body;

Requiring body has an option of providing shares to land owners as 25% of the determined market value at the option of the landowners.

12.6.3 Land Acquisition Requirement

To Improve deficient geometry and to upgrade project highway into four lane pave shoulder configuration with enhancement of project facilities by Truck lay bye, Toll plaza, Q-bus shelter approx. 135.441 Ha. land will be required.

The process of land acquisition has already been started with submission of 3(a) notification for appointment of Competent Authority for land acquisition.

The details of Villages, Taluka, District & Police station for land acquisition requirement is as below:

Table 12.9: Detail of Villages for Land Acquisition Requirement

S. No.	Stretch of Land	District	Taluka	Police Station	Name of Village
1	Km 50/925 to 25/086	Jamnagar	Kalavad	Kalavad	Sarvaniya
					Kalavad
					Jashapar
					Kalavad
					Nana Badanpar
					Haripar (Khandhera)
					Khandhera
					Vodisang
					Moti Matli
2.	Km 32/000 to 3/665	Jamnagar	Jamnagar	Jamnagar	Dhudasiya
					Matva
					Modpar
					Pasaya
					Modpar
					Sapda
					Vijarkhi
					Mota Thavariya
					Theba
					Jamnagar

The details of land acquisition of Draft stage in summarized form are as below. Detail verification & 3(A) notification under progress.

Table 12.10: Summary of Land Acquisition

S. No.	Existing Km		Design Chainage		Length (m)	Remarks
	From	To	From	To		
1	50+925	Bypass	0.000	0.100	100	Proposed Kalavad Bypass
2	Bypass	Bypass	0.100	0.950	850	
3	Bypass	Bypass	0.950	1.500	550	
4	Bypass	Bypass	1.500	4.490	2990	
5	Bypass	Bypass	4.490	4.710	220	
6	Bypass	Bypass	4.710	4.740	30	
7	Bypass	Bypass	4.740	4.810	70	
8	Bypass	42+962	4.810	9.400	4590	
9	42+962	41+942	9.400	10.420	1020	
10	41+942	41+752	10.420	10.610	190	
11	41+752	41+521	10.610	10.840	230	
12	41+521	41+331	10.840	11.030	190	
13	41+331	41+260	11.030	11.100	70	
14	41+260	40+641	11.100	11.700	600	
15	40+641	40+611	11.700	11.730	30	
16	40+611	40+420	11.730	11.920	190	
17	40+420	39+387	11.920	12.970	1050	
18	39+387	39+267	12.970	13.090	120	
19	39+267	39+197	13.090	13.170	80	
20	39+197	39+067	13.170	13.290	120	
21	Re-alignment	Re-alignment	13.290	14.400	1110	Haripar Realignment
22	37+958	36+369	14.400	16.000	1600	
23	Re-alignment	Re-alignment	16.000	17.350	1350	Khandera Realignment
24	34+450	32+826	17.350	19.000	1650	
25	32+826	32+619	19.000	19.200	200	Curve Improvement
26	32+619	31+771	19.200	20.050	850	
27	31+771	31+507	20.050	20.300	250	Curve Improvement

S. No.	Existing Km		Design Chainage		Length (m)	Remarks
	From	To	From	To		
28	31+507	29+508	20.300	22.300	2000	
29	29+508	29+205	22.300	22.590	290	Curve Improvement
30	29+205	29+000	22.590	22.800	210	
31	29+000	28+568	22.800	23.200	400	Curve Improvement
32	28+568	28+258	23.200	23.510	310	
33	28+258	28+068	23.510	23.700	190	
34	28+068	26+527	23.700	25.250	1550	
35	26+527	26+261	25.250	25.500	250	Curve Improvement
36	26+261	22+589	25.500	29.060	3560	
37	22+589	22+399	29.060	29.250	190	
38	22+399	22+116	29.250	29.530	280	
39	22+116	21+945	29.530	29.720	190	
40	21+945	21+155	29.720	30.500	780	
41	21+155	20+786	30.500	30.850	350	Curve Improvement
42	20+786	20+113	30.850	31.530	680	
43	20+113	19+901	31.530	31.730	200	
44	19+901	19+792	31.730	31.840	110	
45	19+792	19+601	31.840	32.030	190	
46	19+601	18+337	32.030	33.275	1245	
47	18+337	18+142	33.275	33.470	195	
48	18+142	18+063	33.470	33.550	80	
49	18+063	17+313	33.550	34.300	750	Curve Improvement
50	17+313	17+093	34.300	34.520	220	
51	17+093	16+722	34.520	34.900	380	
52	16+722	16+074	34.900	35.500	600	Curve Improvement
53	16+074	14+471	35.500	37.100	1600	
54	Re-alignment	Re-alignment	37.100	39.500	2400	Vijarakhi Realignment
55	11+840	11+668	39.500	39.670	170	
56	11+668	10+835	39.670	40.500	830	
57	10+835	10+715	40.500	40.620	120	

S. No.	Existing Km		Design Chainage		Length (m)	Remarks
	From	To	From	To		
58	10+715	10+524	40.620	40.810	190	
59	10+524	10+465	40.810	40.870	60	
60	10+465	10+335	40.870	41.000	130	
61	10+335	10+275	41.000	41.060	60	
62	10+275	9+911	41.060	41.400	340	
63	9+911	9+681	41.400	41.630	230	
64	9+681	9+231	41.630	42.080	450	
65	9+231	7+383	42.080	43.900	1820	
66	7+383	7+183	43.900	44.100	200	
67	7+183	6+347	44.100	44.970	870	
68	6+347	6+237	44.970	45.080	110	
69	6+237	6+157	45.080	45.160	80	
70	6+157	6+037	45.160	45.280	120	
71	6+037	5+964	45.280	45.350	70	
72	5+964	4+651	45.350	46.660	1310	
73	4+651	4+481	46.660	46.830	170	
74	4+481	4+431	46.830	46.880	50	
75	4+431	3+720	46.880	47.572	692	

12.6.4 National Resettlement and Rehabilitation Policy, 2007

The National Rehabilitation and Resettlement Policy, 2007 (NRRP, 2007) was adopted by the Government of India on 31 October 2007 to address development-induced resettlement issues. The NRRP stipulates the minimum facilities to be ensured for persons displaced due to the acquisition of land for public purposes and to provide for the basic minimum requirements. All projects leading to involuntary displacement of people must address the rehabilitation and resettlement issues comprehensively. The State Governments, Public Sector Undertakings or agencies, and other requiring bodies shall be at liberty to put in place greater benefit levels than those prescribed in the NRRP. The principles of this policy may also apply to the rehabilitation and resettlement of persons involuntarily displaced permanently due to any other reason. The objectives of the Policy are:

- (i) To minimize displacement and to promote, as far as possible, non-displacing or Least-displacing alternatives;

- (ii) To ensure adequate rehabilitation package and expeditious implementation of the rehabilitation process with the active participation of the affected families;
- (iii) To ensure that special care is taken for protecting the rights of the weaker sections of society, especially members of the Scheduled Castes and Scheduled Tribes, and to create obligations on the State for their treatment with concern and sensitivity;
- (iv) To provide a better standard of living, making concerted efforts for providing sustainable income to the affected families;
- (v) To integrate rehabilitation into development planning and implementation process; and
- (vi) Where displacement is on account of land acquisition, to facilitate harmonious relationship between the requiring body and affected families through mutual cooperation.

The NRRP is applicable for projects where over 400 families in the plains or 200 families in hilly or tribal or Desert Development Program areas are displaced. However, the basic principles can be applied to resettling and rehabilitating regardless of the number affected. However, the provisions under the NRRP can also be followed for other projects as a standard and best practice. Therefore, the relevant provisions of NRRP are applicable to this project. NRRP's provisions are intended to mitigate adverse impacts on Project Affected Families. The NRRP comprehensively deals with all the issues and provides wide range of eligibility to the affected persons and meets most of the requirement of ADB's Policy on Involuntary Resettlement (1995). The non title holders, under NRRP, are recognized as people living in the affected area not less than three years after the declaration of the area as affected. The NRRP addresses vulnerable families with adequate entitlements and provides special provisions for Scheduled Castes and Scheduled Tribes Families. The NRRP takes into account transparency as far as consultation, dissemination of information, disclosure and grievance is concerned. However, the law relating to the acquisition of privately owned immovable property remains the LAA.

12.7 ENTITLEMENT MATRIX

The entitlement matrix establishes the parameters for mitigations of various losses, based on the experience of MP and CG projects. The matrix recognizes the range of potential or likely losses to be experienced by affected households in future sub projects. The entitlement matrix would apply to additional projects, based on Specific projects impacts. The four/ six-lane road passing through settlements would divide the community and also create hindrances for the people using the social infrastructure in general and Schools, Hospital etc. in particular, which are used by children and sick people.

12.7.1 Eligibility and Entitlements

PAPs entitled for compensation and rehabilitation are (i) PAPs losing land and other assets with legal title/traditional land rights will be compensated, and PAPs will be rehabilitated (ii) tenants; (iii) owners of buildings, crops, plants, or other objects attached to the land; (iv) PAPs losing business, income, and salaries; (v) assistance to the non title holders(squatters, etc). Compensation eligibility is limited by a cut-off date as set for the Project on the day of the PAP census survey. It is on this date that all impacted persons will be identified and the nature of the impact disclosed. PAPs who settle in the affected areas after the cut-off date will not be eligible for compensation and/or other assistance. They, however, will be given sufficient advance notice, requested to vacate premises and dismantle affected structures prior to Project implementation. Their dismantled structures will not be confiscated and they will not pay any fine or suffer any sanction.

The details of entitlement as against loss could be seen from the following entitlement matrix **Table 12.11.**

Table 12.11: Detailed Entitlement Matrixes

Code	Category of PAP	Type of Impact	Unit of Entitlement	Entitlement	Remarks
1A	Titleholder-Agriculture land/ non-agriculture land/ Homestead land and assets	Loss of land and assets	Land owners	1. Cash compensation at “actual market values”. 2. Option for compensation of residual unviable land parcels. 3. Registration and stamp duly charges (currently applicable) for the land acquired. 4. All fees, taxes and other charges, as applicable under the relevant laws, shall be borne by the project. 5. Replacement of water-yielding bores shall be done subject to availability of water in the remaining landholding or anywhere near the beneficiary land in consultation with the affected community, if water is not available, replacement cost of the bore-well at rates decided on case-by case (without depreciation) based on Gujarat water Supply and sewerage Board (GWSSB) schedule of rates. 6. Financial assistance for replacement of cattle shed: one-time financial assistance of Rs. 15000 for displaced household. 7. In case land owners become landless or marginal,	1. Compensation shall be determined as per LA Act 1894. Difference, if any, between the compensation award as per the LA Act, 1894 and the market value, shall be paid by the project in the form of assistance. The updated guideline/ Jantri values will be adopted for determination of actual market value to be acquired. 2. Compensation for Timber Trees shall be decided by Forest Department, Gujarat. Compensation for perennial trees and standing crops shall be decided by Agriculture and Cooperation Department, Gujarat. 3. The rates for determination of assistance and compensation shall be revised annually during the project implementation period. The revision shall be effected from the

Code	Category of PAP	Type of Impact	Unit of Entitlement	Entitlement	Remarks
				financial assistance, equivalent to 12 months of minimum agricultural wages of Gujarat (Calculated for 25 day in a month), as subsistence allowance. 8. Ex-gratia assistance of Rs. 20000 for land owners losing upto 500 sq.m of land in lieu of all other benefits. 9. In case of severance of agricultural land, an additional grant of 10 percent of the amount paid for land acquisition. 10. Advance notice of 4 months to harvest standing crops. 11. Crop/tree damage compensation as assessed by the concerned Governments. 12. Right to salvage materials from affected land or structure.	1st day of April every year. The real value of monetary compensation and assistance shall be assessed as follows; (1) Compensation for land shall be based on updated jantri value. (2) Compensation for structure/assets shall be based on updated Schedule of Rates. 4. Allowances and assistances shall be based on Consumer price index (CPI), updated 1st of April every year. In case, if Jantri value or schedule of Rates is not updated by 1st of April, Compensation and assistance shall be provided based on existing rates. Differences if any, between the existing rates and the updated rates will be provided by the project after publication of the updated rates.
1B	Titleholder-Residential Structure	Loss of structure	Land/structure owner(s)	1. Compensation at “replacement cost” determined on the basis of R& BD schedule of rates as on date without depreciation.	

Code	Category of PAP	Type of Impact	Unit of Entitlement	Entitlement	Remarks
				2. Affected structures of size less than 20 sqm., which are fully affected or if rendered unviable, shall have option to compensation equivalent to cost of provision of residential structure of size 20 sqm. 3. Shifting Allowance: one-time financial assistance of Rs. 10,000. 4. Transitional allowance of Rs. 10,000 towards temporary arrangements and rentals during the transition period. 5. Right to salvage materials from affected land or structure.	
IC	Titleholder-commercial/ Industrial structure	Loss of structure	Land/ structure owner(s)	1. Compensation at replacement cost determined on the basis of R & BD schedule of rates as on date without depreciation. 2. Affected structures of size less than 10 sqm which are fully affected, or rendered unviable, shall have option to compensation equivalent to cost of provision of commercial structure, of size 10 sqm. 3. Shifting Allowance: one-time financial assistance of Rs. 10,000. 4. Transitional allowance of Rs. 10,000 towards temporary arrangements and rentals during the	

Code	Category of PAP	Type of Impact	Unit of Entitlement	Entitlement	Remarks
				transition period. 5. Right to salvage materials from affected land or structure.	
ID	Titleholder-Residential-cum-commercial/industrial structure	Loss of Structure	Land/structure owner(s)	1. For tenants (Residential category) requiring relocation, rental allowance for 6 months at the rate of Rs. 1000/ month in rural areas and Rs. 1500/month in urban areas, if the structure is fully affected or the unaffected part of the structure is unviable. 2. For tenants (commercial/ industrial category), requiring relocation, rental allowance for 6 months at the rate of Rs. 1500/month in rural areas and Rs. 2000/month in urban areas, if the structure is fully affected or the unaffected part of the structure is unviable. 3. Shifting Allowance: one-time financial assistance of Rs. 5000. 4. For impacts to structures contracted by the EP, compensation at replacement cost determined on the basis of R&BD schedule of rates as on date without depreciation. 5. Right to salvage materials from affected land or structure.	

Code	Category of PAP	Type of Impact	Unit of Entitlement	Entitlement	Remarks
3A	Squatter-Residential/ commercial/ Residential-cum-commercial	Loss of structure	Individual/ household	1. Compensation for impacted structures at replacement. 2. Cost determined on the basis of R&BD schedule of rates as on date without depreciation (or) (i) Cost towards land and house construction (of area as applicable to EWS housing scheme in Gujarat), for residential squatters. (ii) Costs towards land and shop contraction (of 100 sq area) for commercial squatters, whichever is higher among 3A. 3. Shifting Allowance: one time financial assistance of Rs. 5000. 4. Training Assistance for Income Generation: Training in opted areas to any one member of the household losing livelihood. Training cost upto a maximum of Rs. 15000 shall be borne by the project implantation authority.	
3B	Encroachers	Loss of Assets	Household	1. Ex-gratia for impacted assets at replacement cost. 2. Encroachers shall be given advance notice of 4 months in which to remove assets (except trees), and harvest standing crops, if any.	

Code	Category of PAP	Type of Impact	Unit of Entitlement	Entitlement	Remarks
4A	Additional suppose to vulnerable groups		Individual/ Household	1. Training Assistance for income Generation: Training in opted areas to any one member of the household losing livelihood. Training cost upto a maximum of Rs. 15000 shall be borne by the project implementation authority. (or) 2. Lump sum amount of Rs. 15000 as grant to those who cannot be provided with alternative livelihood sources.	
5A	Employees in shops, agricultural labours, sharecroppers	Loss of livelihood	Individual	1. Training Assistance for income Generation: Training in opted areas to any one member of the household losing livelihood, training cost upto a maximum of Rs. 15000 shall be borne by the project implementation authority. (or) 2. Lump sum Financial assistance equivalent to 6 months of minimum agricultural wages o Gujarat (calculate for 25 days in a month), to those who cannot be provided with training on alternative livelihood opportunities.	

Source: Roads and Building Department Government of Gujarat.

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12.8 R&R BUDGET

The budget is indicative of outlays for the different expenditure categories and will be calculated as per price index later after detailed socio-economic survey and census survey of the PAPs. Some of the features of cost estimate are outlined below:

- ❖ The land will be compensated at replacement value worked out based on the methods given in the entitlement framework;
- ❖ MoRTH will compensate the structures at replacement value to the legal titleholders and to the squatters/encroachers, assisted by the NGO.

12.9 IMPLEMENTATION SCHEDULE

The proposed subproject R&R activities are divided in to three broad categories based on the stages of work and process of implementation. The details of activities involved in these three phases, i.e. Project Preparation Phase, RP Implementation phase, Monitoring and Evaluation period are discussed in the following paragraphs.

The major activities to be performed in this period include establishment of PMU and PIU at project and subproject level respectively; submission of RP for PWD approval; appointment of NGO and establishment of GRC etc. The information campaign & community consultation will be a process initiated from this stage and will go on till the end of the project.

After the project preparation phase the next stage is implementation of RP which includes issue compensation of award by EA; payment of all eligible assistance; relocation of APs; initiation of economic rehabilitation measures; site preparation for delivering the site to contractors for construction and finally starting civil work.

12.10 GRIEVANCE REDRESS COMMITTEE

A Grievance Redress Committee (GRC) at PIU level will be formed to deal with the disputes and AP's grievance and facilitate timely implementation of the Project. The GRC will be headed by the DC or a representative from the collector's office. The GRC will have R&R officer from the PIU office, representatives of APs, local government representatives, and NGO. The GRC will meet as and when grievances are referred to it for redress. Other than disputes relating to ownership rights under the court of law, GRC will review grievances involving all resettlement benefits, compensation, relocation, and other assistance.

12.10.1 Monitoring and Evaluation

Monitoring and Evaluation (M&E) are critical activities in involuntary resettlement management and helps in order to ameliorate problems faced by the APs and develop solutions immediately. RP implementation for the subproject will be closely monitored by PMU internally.

The PIU responsible for supervision and implementation of the RP will prepare monthly progress reports on resettlement activities and submit to PMU. PMU will submit quarterly reports to PWD. The independent monitoring & evaluation expert will be hired under construction supervision consultation by EA in agreement with PWD to undertake overall monitoring of the subproject will submit a biannual review directly to PWD and determine whether resettlement goals have been achieved, more importantly whether livelihoods and living standards have been restored/enhanced and suggest suitable recommendations for improvement.

12.11 CONCLUSION

The impact of roads projects on people and their communities are important and are increasingly having greater influence on the route alignment decisions and road design. SIA methods help to identify the potential impacts and to avoid, reduce, eliminate, or compensate the social impacts.

- Reduces the data collection for linear projects, reducing the time and cost;
- Helps to resolve the issues by developing an effective working relationship to allow the public and the project team to address the issues;
- Help to reduce the need for lengthy hearings and other project delays based on the public concern or opposition to the project;
- Can often assist the project management by helping to transform the public issues into manageable design standards and revised construction practices.

Road Projects entail a variety of adverse impacts and benefits as well. The project impacts include loss of land (agricultural, residential and commercial), Structures (Residential, commercial and Community), income and livelihood (owners, tenants, encroachers and squatters) and religious and cultural sites. Major impacts of the project include loss of agricultural land due to acquisition along the road and provision of elevated road.

To enhance project benefits for roadside communities and road users, the project design has incorporated the following:

- Improvement of geometric deficiencies;
- Provision of Grade separator wherever traffic demand and guide line permits
- Separate provision of footpaths;
- Provision of anti-crash barriers;
- Slope protection;

- Effective surface and sub-surface drainage system to ensure that there shall be no ponding of water on the highway and the adjacent area;
- Safety measures such as pedestrian rails, barriers, highway signs, pavement marking, traffic signals landscaping, illumination, Road furniture, truck lay-byes, and bus bays;
- Other benefits include:
 - (a) Saving in vehicle operating cost;
 - (b) Time saving- freight and passenger movement;
 - (c) Employment potential-direct employment in road construction and allied Activities and greater mobility;
 - (d) Lower accidents, quick access to services like hospitals, markets, offices etc.



CHAPTER - 13
PRELIMINARY COSTING OF PROJECT

CHAPTER-13

PRELIMINARY COSTING OF PROJECT

13.1 GENERAL

The Site of the Two-Lane Project Highway comprises the section of National Highway 927D start from km 50+925 to km 3+720 i.e. the Kalavad to Jamnagar section in the State of Gujarat.

This chapter provides preliminary cost estimate of 4-Lane with paved Shoulder configuration of Kalavad to Jamnagar (0.000 to 47.572) of NH 927D in the state of Gujarat.

13.2 METHODOLOGY

The following procedure has been adopted for estimation:

- Road work: The quantities of earth work, pavement and other appurtenances have been worked out as per pavement design, widening scheme and typical cross sections adopted. Costing for every TCS is done to calculate the per km cost of each type of cross section.
- Cost of Junctions, Service Roads, Crash Barriers, Bus bays, Truck Lay Bye etc. have been calculated based on standard drawings and design.
- Costing of Civil works of Toll Plaza is based on Plan area. Miscellaneous costs have been calculated as per requirement and rates suitably adopted.
- Costs of Major/Minor Bridges/Elevated Road/FO/VUP have been calculated on block cost basis.
- RCC Covered drains have been proposed to be constructed in the urban areas and unlined drains are proposed to be constructed in the rural areas as indicated in TCS drawings.
- Provision has been made for traffic safety features, road furniture and road markings based on the experience on similar other roads in confirmation with relevant codes and manuals.
- Lighting of Main Carriageway has been suitably considered for all urban sections, Approaches to structures, Toll Plaza, Truck Lay Bye and Bus Bay.
- High Mast lights have been considered at Toll Plaza and Major Junctions.

13.3 UNIT COST

- The rates given in Basic Schedule of rates 2023-24 NH Division Rajkot (Gujarat) are used for estimation purpose. For non BSR items our rate analysis is used.
- Adopted Rates of important items are given in Table 13.1.

Table 13.1: Adopted Rates of Important Items

S. No.	Item	Unit	Rate (Rs)
1	Earth Work excavation for road way and drain in ordinary soil	m ³	70.30
2	Earth work for fill from borrow areas	m ³	334.64
3	Granular Sub-Base	m ³	1875.14
4	Wet Mix Macadam	m ³	1844.82
5	Dense Bituminous Macadam	m ³	8692.00
6	Bituminous Concrete	m ³	10163.00
7	Cement Concrete Kerb	Rmt	234
8	Road Marking with Thermoplastic Compound	Sqm	412
9	PCC M-15 in Foundation	cum	3786
10	HYSD Reinforcement	MT	84984

13.4 PAVEMENT DESIGN OPTIONS

Three types of Pavement options considered while designing pavement from economical point of view flexible pavement, Flexible pavement using Cement treated granular Sub base and Rigid Pavement. Following are the crust composition is adopted as per the pavement design proposed.

Table 13.2: New Pavement Design for 8% CBR

Section	Direction	Design CBR	Design Traffic (MSA)	Pavement Layer Thickness					
				BC (mm)	DBM (mm)	AIL (mm)	CTB (mm)	GSB (mm)	Total Thickness (mm)
Widening from km 3+720 to km 50+925	LHS	8%	51	40	60	100	165	200	565
	RHS	8%	35	40	60	100	165	200	565
Kalavad Bypass	-	8%	34	40	60	100	165	200	565

CHAPTER - 14

ECONOMIC ANALYSIS

CHAPTER - 14

ECONOMIC ANALYSIS

14.1 INTRODUCTION

14.1.1 Background

As per the Terms of Reference (TOR), this report has been prepared documenting the economic evaluation of up gradation/ strengthening of highway corridor Dhoraji-Kalawad Section of NH-927D. The Corridor under study starts near Kalawad at Existing km 50+925 of SH-26 and ends at Existing km 3+720 of SH-26. It is presently intermediate lane to 2-lane Road and this section of the highway is proposed for Upgrading to 2/4 lane configurations with paved shoulder

14.1.2 Objective

The objective of project evaluation is to assess the Economic viability of upgrading of the existing intermediate lane to 2-lane road and this section proposed for 4-lane configuration with paved shoulder and construction of bypass. The economic viability is to be evaluated in terms of Economic Internal Rate of Return (EIRR).

14.2 BASIC APPROACH AND METHODOLOGY

14.2.1 Basic Approach

Economic Analysis of an infrastructure project is undertaken to ascertain the importance and benefits of the project to the society at large. The road project has been proposed for improvement in order to provide higher speeds as well as better riding quality to the traffic on this corridor. These improvements will result in reduction in the travel time as well as the vehicle operating costs of the passengers/cargo/vehicles. There is a cost attached to the improvements provided. These are the initial improvement cost, environmental and social cost as well as the maintenance cost which are anyway required to keep the improved facility in good condition. Since the infrastructure projects are social projects, it is important to justify its need from the perspective of the community.

The present study envisages the use of Highway Development and Management Model, hereafter referred as HDM-4 (An analytical tool for engineering and economic assessment of road investments and maintenance).

HDM-4 (Version 2) model is designed to be used in a wide range of environments. Configuration of HDM-4 provides the facility to customize system operation to reflect the norms that are customary in the environment under study. Default data and calibration

coefficients are defined in a flexible manner to minimize the amount of data that must be changed for each application of HDM-4.

In the economic appraisal all the financial estimates of costs and benefits are converted to economic costs by applying a conversion factor varying from 0.8 to 0.9.

The cost stream comprises of:

- Capital cost of construction of the project road and related works.
- Annual repair and maintenance cost
- Operating cost of vehicles

The benefit stream comprises of:

- Savings in Vehicle Operating Costs (VOC);
- Savings in travel time costs due to reduction in congestion and higher travel speeds as a result of improved roads - both in terms of capacity as well as riding quality;
- Savings in maintenance costs.

The cost of the project is further subtracted from benefits accruing year wise and discounted to work out the Economic Internal Rate of Return (EIRR) and Net Present Value (NPV).

14.2.2 Methodology for Economic Analysis

1. Collection of Basic Input Data

- **Road Network Data-** Road inventory, pavement condition survey data, existing road geometry, pavement (structure, strength & condition), subgrade strength and construction /maintenance history derived from field survey and investigations.
- **Traffic Data-** The traffic data in terms of Annual Average Daily Traffic (AADT) and their % distribution in terms of Motorized Traffic & Non-Motorized Traffic is to be considered.
- **Vehicle Fleet Data-** Vehicle Operating Costs (VOC) is the major component of economic analysis. The primary inputs required in HDM to estimate the VOCs in the form of cost are vehicle price, tyre, petrol, diesel, lubricants, crew cost, maintenance cost, vehicle utilization and other vehicle fleet characteristics data.
- **Sectioning of Project Corridor-** Based on the road network data mentioned above the project corridor to be divided into homogenous sections.

2. Project Cost & Maintenance Cost- The Project Cost is the sum of Basic Civil Cost, Social Cost & Environmental Mitigation/Improvement Cost, and the Maintenance cost

occurs in the form of Routine & Periodic Maintenance. The financial estimates of costs are converted to economic costs by applying a conversion factor of 0.9.

- 3. Analysis of Input Data-** The above collected data is further analysed for calculating Economic Internal Rate of Return (EIRR) and Net Present Value (NPV) of the project. And thus, the economic viability of the project is proven.

14.3 DEFINITION OF “WITHOUT PROJECT” AND “WITH PROJECT” SITUATION

The appraisal has been carried out within the framework of “Without Project” and “With Project” situations.

- Without Project situation is the one in which the projected traffic would continue to move on the existing two-lane road which will require certain minimum routine and periodic maintenance for upkeep of the facility.
- With Project situation is the one in which the traffic would use the improved facility, which is Four lane carriageways with paved shoulders facility.

14.4 INPUTS FOR HDM-4

The input data used in the HDM-4 model for the project road are as follows:

14.4.1 Homogenous Sections

Based on the traffic, pavement condition data (cracking, potholes, etc.), roughness, horizontal & vertical profile and cost impact on project proposals, the project corridor is divided into 5 sections. The sectioning details are as given below:

Table 14.1: Sectioning of Project Corridor for analysis

S. No.	Section Name	From (km)	To (km)	Length (km)
1	S-01*	0+000	9+430	9.430
2	S-02	9+430	15+783	6.353
3	S-03	15+783	32+583	16.800
4	S-04	32+583	39+318	6.735
5	S-05	39+318	47+572	8.254
Total Length (in km)				39.309

* Kalavad Bypass

14.4.2 Traffic data

Traffic data has been derived from the volume count surveys conducted at km 9+430. A detailed analysis on derivation of section- wise traffic has been presented in **Chapter 4**. The Traffic in nos. for the Vehicle Fleet Data adopted for economic analysis is given in **Table 14.2**.

Table 14.2: Traffic Composition

Categories	Section 1	Section 2 to 5
2-Wheeler	2,508	5,015
3-Wheeler	286	571
Passenger Car	889	3,182
Standard Bus	87	190
Mini Bus	3	8
Mini LCV + LCV	334	869
2-Axle	128	417
3-Axle	70	148
MAV (4 to 6 Axle)	85	193
OSV	0	0
HCM +Tractors-With/Without Trailer	60	119
Total MT Traffic	4,450	10,712
Bi-Cycle	3	5
Cycle-Rickshaw	0	0
Animal-Drawn	0	0
Hand-Drawn	0	0
Total NMT Traffic	3	5

14.4.3 Traffic Growth

The traffic growth considered for Economic Analysis is as follows:

Table 14.3: Adopted Traffic Growth

Categories	Section 1	Section 2 to 5
2-Wheeler	5%	5%
3-Wheeler	5%	5%
Passenger Car	5%	5%
Standard Bus	5%	5%
Mini Bus	5%	5%

Categories	Section 1	Section 2 to 5
Mini LCV + LCV	5%	5%
2-Axle	5%	5%
3-Axle	5%	5%
MAV (4 to 6 Axle)	5%	5%
OSV	5%	5%
HCM +Tractors-With/Without Trailer	5%	5%
Bi-Cycle	5%	5%
Cycle-Rickshaw	5%	5%
Animal-Drawn	5%	5%
Hand-Drawn	5%	5%

14.4.4 Road Network Data

Information on road network has been obtained from field surveys. **Table 14.4** below presents the basic road network data used as input for undertaking the economic analysis of project corridor. The given list of pavement types and its characteristics, form input for HDM-4. The details of existing road sections data are given in **Table 14.4.** and details of improved road section data has been presented in **Table 14.5.**

Table 14.4: Existing Road Network Data

Parameters	S-02	S-03	S-04	S0-5
Geometric Parameters				
Road Length (km.)	6.353	16.8	6.735	8.254
Carriageway Width (m)	6.10	6.10	6.10	6.10
Shoulder Width(m)	0	0	0	0
Number of Lanes	2	2	2	2
Rise + Fall (m/km)	10	10	10	10
No of Rise + Fall (No/km)	1	1	1	1
Avg. Horizontal Curvature(deg/km)	10	10	10	10
Speed Limit (km/hr)	35	35	35	35
Average Superelevation (%)	3	3	3	3
Altitude (m)	90	115	129	118
Pavement Parameters				
Pavement type	Flexible with Stabilised Base			
Thickness of Recent Surfacing Layers(mm)	100	100	100	100
Thickness of Old Surfacing Layers(mm)	0	0	0	0
Last reconstruction/rehabilitation Year	2015	2015	2015	2015

Parameters	S-02	S-03	S-04	S0-5
Deflection (mm)	1.20	1.75	1.51	1.36
Subgrade CBR (%)	8	8	8	8
Surface Condition				
Year of Condition Survey	2015			
Roughness (IRI - m/km)	3.85	4.83	4.35	4.29
Total Area of Structural Cracking (%)	0	6	0	2
Ravelling Area (%)	0	3	7	1
No. of Potholes (no./km)	0	0	0	2
Edge Break Area (sq.m/km)	0	0	0	0
Mean Rut Depth (mm)	0	0	0	0
Rut Depth Standard Deviation(mm)	0	0	0	0
Texture Depth (mm)	0.50	0.50	0.50	0.50
Relative Compaction (%)	97	97	97	97
Skid Resistance (SCRIM 50km/hr)	0.50	0.50	0.50	0.50

Table 14.5: Improved Condition Road Network Data

Parameters	S-01	S-02	S-03	S-04	S0-5
Geometric Parameters					
Road Length (km.)	9.430	6.353	16.8	6.735	8.254
Carriageway Width (m)	14	14	14	14	14
Shoulder Width(m)	1.5	1.5	1.5	1.5	1.5
Number of Lanes	4	4	4	4	4
Rise + Fall (m/km)	10	10	10	10	10
No of Rise + Fall (No/km)	1	1	1	1	1
Avg. Horizontal Curvature(deg/km)	10	10	10	10	10
Speed Limit (km/hr)	100	100	100	100	100
Average Superelevation (%)	3	3	3	3	3
Altitude (m)	90	90	115	129	118
Pavement Parameters					
Pavement type	Flexible with Stabilised Base				
Thickness of Surfacing Layers(mm)	40	40	40	40	40
Thickness of Base Layer (mm)	165	165	165	165	165
Modulus of Base Layer (MPa)	5000	5000	5000	5000	5000
Surface Condition					
Year of Completion	2027				
Roughness (IRI - m/km)	2	2	2	2	2

14.5 PROJECT COST AND SCHEDULING

- **Capital Cost-** Capital cost is the cost for with project case, which comprises of Cost of Civil Works, Social & Utility cost, and Environmental Mitigation/Improvement Cost.
- **Maintenance Cost-** Maintenance cost is normally incurred in two phases: Routine Maintenance and Periodic Maintenance. Routine. Routine Maintenance comprises Patching, Crack Sealing, Edge Repair and Shoulder Repair while Periodic Maintenance comprises overlay and Shoulder Repair.
- **Schedule of Construction-** In the present study of up gradation for two lanes with gravelly shoulder, the period of construction is taken as 910 days.

14.5.1 Capital Cost and Phasing

- **Capital Cost-** As discussed above the Capital Cost in context of Project follows as:

Table 14.6: Capital Cost (in crore)

S. No.	Description of Item	S-01 (Bypass)	S-02 to S-05 (Re-construction)	Total
Project Length (km)		9.430	38.142	47.572
1	Total Civil Construction Cost (Cr.)	232.51	469.84	702.35
2	Financial Civil Construction Cost (Cr./km)	24.66	12.32	-
3	Economic Civil Construction Cost (Cr./km)	22.19	11.09	-

Unlike other components of project costs, land to be acquired for the project does not depreciate over time. Although, there would be certain loss to the economy due to acquisition of land (predominantly barren and agricultural) during construction stage, it is expected that enhanced economic activities caused by the project in the adjoining area would well compensate the same. No provision as such is available in HDM-4 to account for such benefits. In view of this, cost of land acquisition has not been included in the base evaluation.

- **Phasing-** Since as a reconstruction proposal four lanes with paved shoulder has been proposed a construction period of 730 days (2025 - 2027) has been envisaged with a phasing of 50%, 50%.

14.5.2 Maintenance Cost

As discussed above the Maintenance Cost incurs in the form of Routine & Periodic Maintenance, wherein Routine maintenance takes care of minor cracks on the pavement, by

providing a scaling layer on it, whereas, the periodic maintenance is provided as a roughness corrective layer, which is comparatively thick. The pavement deterioration model forms the base for identification of the years when the project corridor would require periodic maintenance (as the balance would be routine maintenance). The years in which periodic maintenance would be required in every 5 years and the balance with routine maintenance. The maintenance strategy and the cost are given in the **Table 14.7**.

Table 14.7: Maintenance Strategy and Cost

Particulars	Maintenance Strategy (Scheduled/Responsive)		Maintenance Cost (Rs.)	
	Base Case	Improved Scenario	Economic	Financial
Overlay with 40mm BC	Scheduled at every 6 years	Scheduled at every 6 years	324 / m ²	360 / m ²
Patching	Scheduled at every 6 years	Scheduled at every 6 years	135 / m ²	150 / m ²
Edge-Repair	Scheduled at every 6 years	Scheduled at every 6 years	180 / m ²	200 / m ²
Drainage Maintenance	Scheduled every year	Scheduled every year	4500 / km	5000 / km
Edge Breaking	Edge Break ≥ 5 m ² /km	Edge Break ≥ 10 m ² /km	180 / m ²	200 / m ²
Pothole Patching	Potholing ≥ 5 no./km	Potholing ≥ 10 no./km	225 / m ²	250 / m ²
Crack Sealing	Wide Structural Cracking $\geq 5\%$	Wide Structural Cracking $\geq 10\%$	45/ m ²	50/ m ²
Shoulder Repair	Scheduled every year	Scheduled every year	10800/ km /year	12000/ km/ year

14.6 PROJECT BENEFITS

The Project Benefits comprise the cost saving in operation of vehicles and maintenance of the road between Without Project and With Project options. The Project Benefits results in the form of-

- Savings in Vehicle Operating Costs (VOC);
- Savings in travel time costs due to reduction in congestion and higher travel speeds as a result of improved roads - both in terms of capacity as well as riding quality;
- Savings in maintenance costs.

14.6.1 VOC Savings

Among the benefit streams discussed above VOC is the major component of economic

analysis. The primary inputs required in HDM, to estimate the VOCs, are the prices of vehicles, tyre, petrol, diesel, lubricants, crew cost, maintenance cost, vehicle utilization, and other vehicle fleet characteristics as given in **Table 14.8 & Table 14.9**.

The Vehicle operating cost (VOC) is a function of Speed, Road roughness, Carriageway, Width/Capacity, Rise and Fall Per unit VOCs are calculated from the sum of distance related and time related VOCs, which include the following:

Distance Related VOCs:

- Fuel Costs
- Maintenance Costs – including spare parts and labour
- Tyre Cost
- Oil Consumption cost

Time-related VOCs

- Opportunity Cost of capital
- Depreciation Cost
- Cost of Crew

The VOCs is estimated using the equations inbuilt in the model.

Table 14.8: Vehicle Fleet Data (Motorised Traffic-MT)

Vehicle Type	Two Wheelers	Three Wheelers	Car	Standard Bus	Mini Bus	LCV	2Axle Truck	3Axle Truck	MAV	Tractor
Vehicular Parameters										
Base Type	Two Wheelers	Autos	Car medium	Bus medium	Std. Mini Bus	Truck Light	Truck Medium	Truck Heavy	Truck Heavy	Tractor
PCSE	0.5	0.75	1	1.5	1.2	1.3	1.5	1.6	2.2	1.5
No. of Wheels	2	3	4	6	4	4	6	10	14	4
No. of Axles	2	2	2	2	2	2	2	3	4	2
Tyre Type	Bias-Ply	Bias-Ply	Redial ply	Bias-Ply	Bias-Ply	Bias-Ply	Bias-Ply	Bias-Ply	Bias-Ply	Bias-Ply
Base number of Recaps	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Retread Cost (%)	15	15	15	20	15	15	15	15	15	15
Annual kilometre (km)	10000	45000	25000	90000	60000	50000	90000	86000	99000	15000
Working Hours (hrs)	400	2000	1200	2300	2000	1400	2600	2050	1500	2000
Average Life (Years)	10	12	15	15	8	12	15	14	10	12
Private Use (%)	100	100	90	0	0	0	0	0	0	100
Passengers (persons)	2	5	4	42	20	0	0	0	0	1
Work related passenger trips (%)	75	60	75	50	90	0	0	0	0	0
Operating weight (tons)	0.2	0.6	1.2	11	7	8.5	16.6	13	35	5
ESALF	0	0	0	0.8	0.8	0.31	7.62	7.56	14.09	14.06

Vehicle Type	Two Wheelers	Three Wheelers	Car	Standard Bus	Mini Bus	LCV	2Axle Truck	3Axle Truck	MAV	Tractor
Economic Unit Costs										
New Vehicle (Rs)	49606	88120	391519	1011121	450000	5986386	1047230	11811850	11811850	350000
Replacement Tyre (Rs)	900	750	2706	9150	4235	4235	8582	8582	8582	2000
Fuel (Rs per litre)	80	80	80	80	80	80	80	80	80	80
Lubricating oil (per litters)	315	315	500	500	500	500	500	500	500	500
Maintenance labours (Rs per hr)	30	30	30	35	34	34	34	35	38	28
Crew Wages (Rs per hr)	0	7	13	24	14	14	27	32	32	10
Annual over head	800	900	5000	24000	10000	8000	24000	24000	24000	6000
Annual interest (%)	12	12	12	12	12	12	12	12	12	12
Passenger working time (Rs per passenger hr)	23	24	39	31	24	0	0	0	0	0
Passenger non-working time (Rs per passenger hr)	6	6	10	8	6	0	0	0	0	0
Cargo (Rs per vehicle hr)	0	0	0	0	0	9	24	28	45	8

Table 14.9: Vehicle Fleet Data (Non-Motorised Traffic-NMT)

NMT	Animal Carts	Bicycles	Cycle Rickshaw
Wheel Type	Wooden	Pneumatic	Pneumatic
No. of wheels	2	2	3
Wheel diameter	1	0.7	0.7
Operating Weight	1200	100	300
Payload	900	35	235
Average life	3	10	6
Working hours	1300	150	500
Annual Km	4000	2500	7200
Passengers	1	1	3
Purchase cost	6000	1500	6000
crew wages	12	12	12
passenger time	0	5.3	5.3
Cargo holding time	1.5	0	0
Energy used	0	0	0
Annual interest	12	12	12

14.6.2 Time Savings

Savings in time results in reduction in congestion and higher travel speeds as a result of improved roads - both in terms of capacity as well as riding quality. The reduction in time saving in terms of capacity is achieved by widening the existing intermediate to two lane with earthen shoulder to two lane/four lane road with paved shoulder. The Speed flow type for the project is given in table below:

Table 14.10: Speed Flow Parameters

Parameter	Two Lane	Four lane + PS
Ultimate Capacity	2000 PCSE/ Lane/Hr	8000 PCSE/ Lane/Hr
Free-Flow Capacity (Proportion at which free-flow condition Ceases)	0.10	0.40
Nominal Capacity, at which speed of all vehicle converges to slowest	0.90	0.95

The riding quality is improved by improving the design standards and improvement in design speed w.r.t. the Terrain Type.

14.7 ECONOMIC INTERNAL RATE OF RETURN (EIRR)

The viability of the Project has been accessed using desirable inputs mentioned above for a period of 30 years including construction period for 12% discount rate, the Salvage value has been considered as 20%. The summarized outcome is shown below:

Table 14.11: Economic Internal Rate of Return (EIRR)

S. No.	Scenario	Condition	EIRR
1	5% Growth Scenario	Base Costs and Base Benefits	13.8%

14.8 CONCLUSIONS

The economic analysis carried out for most likely growth scenario results with **13.8% EIRR** as against minimum 12% (viability acceptance) for a period of 30 years & 12% discount rate.

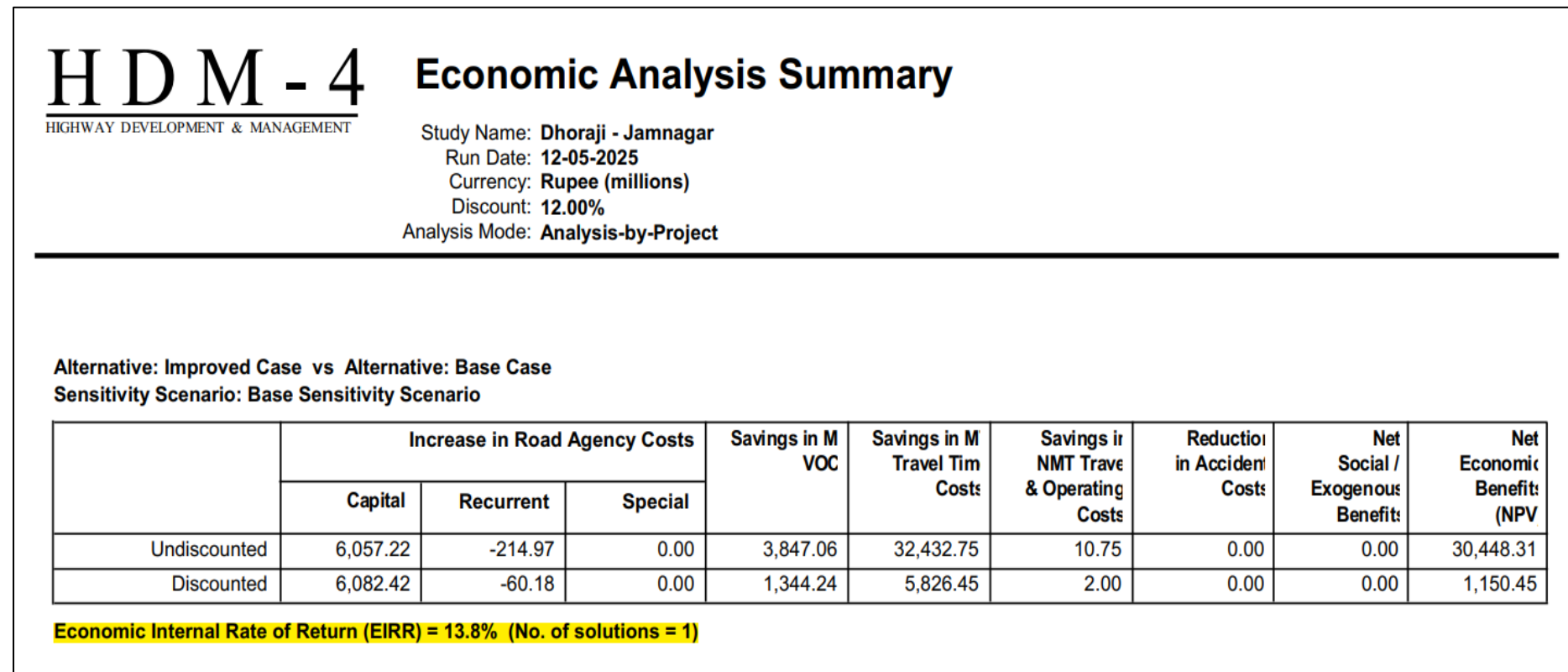


Figure 14.1: HDM-4 Economic Analysis Summary



CHAPTER - 15

FINANCIAL ANALYSIS

CHAPTER - 15

FINANCIAL ANALYSIS

15.1 BACKGROUND

The main objective of financial analysis is to assess the financial viability of the project under Public-Private Partnership (PPP) mode of implementation. Such an analysis would typically require a large number of assumptions to be realistically made at this stage, in order to reflect the actual financial environment at the time of implementation.

For the purpose of financial analysis, the major indicators of project viability are the ability of the project to service the debt raised for the project, as also the returns on equity investment as compared to the prevalent cost of investment in the market, as the opportunity cost of capital. These are measured by computing the Financial Internal Rate of Return (FIRR) for the project, Debt Service Coverage Ratio (DSCR), Financial Internal Rate of Return for Equity etc.

15.2 APPROACHES TO FINANCIAL EVALUATION

As per the Terms of Reference (TOR), this report has been prepared documenting the financial evaluation of up gradation/ strengthening of highway corridor of Kalavad-Jamnagar section of newly declared NH-927D. The Corridor under study starts at Kalavad and ends at Jamnagar. The existing Project Corridor is intermediate lanes to two lanes with earthen shoulder carriageway, proposed to be widened to a four lane.

The viability of the project is evaluated on the basis of Project IRR on total investment. The FIRR is estimated on the basis of cash flow analysis, where both costs and revenue have been indexed to take account of inflation. Financial analysis has been carried out for the entire project road with debt equity ratio of 70:30. The basic indicators for assessing the Financial Viability of the project are as follows.

NPV (Net Present Value): The NPV for the project should be positive when a discount rate representing the opportunity cost along with a risk premium is applied in the financial analysis.

FIRR (Financial Internal Rate of Return): The FIRR should have a value above the discount rate (opportunity cost).

Cash Flow (Liquidity): The cash flow situation should be satisfactory in each year of the concession period. In other words, the cash balance at the end of every year should be positive.

15.3 COST OF THE PROJECT

The Project Cost Assumptions are as follows:

- Contingency cost, IC & Pre-Operative Expenses cost, Financing Cost, Interest during Construction and Escalation have been taken as 25% of Basic civil Cost.
- The Construction cost for the upgradation of the Project road does not include the Environmental, Social, Land Acquisition cost for the purpose of Financial Analysis.

15.3.1 Basic Civil Cost

The cost of civil works of the projects including the improvement of existing carriageway and cost of toll plaza are given below.

Civil Cost of total package from Kalavad to Jamnagar is Rs. 724.12 Crores.

The annual phasing of capital cost is made as per the work schedule. Construction cost is phased over a period of 730 days as 60%:40%.

15.3.2 Cost Escalation

The Escalation cost during construction, which is on the cost of funding incurred on the project, has been included in 25% of Basic civil Cost.

15.3.3 Interest during Construction

The interest during construction, which is on the cost of funding incurred on the project, has been included in 25% of Basic civil Cost.

15.3.4 Total Project Cost

The total landed cost for the project at the end of the construction period has been estimated by adding the (capitalizing) 1.25 times of the Basic civil Cost. The total project cost at the time of commissioning is thus estimated and is given in **Table 15.1**.

Table 15.1: Total Project Cost Summary of Concessionaire Cost (Rs. Crores)

S.No.	Particulars	Cost (In Cr.)
1	Total Civil Cost incl. utility shifting	724.12
2	Other Costs such as IC & Pre-Operative expenses, Financing Cost, Interest during Construction, etc @ 1.25 times of Total Civil Cost	181.03
	Total Project Cost (TPC)	905.15

15.4 OPERATION AND MAINTENANCE COST

The maintenance costs consist of two primary components viz. routine and periodic. Routine maintenance costs comprise of maintenance of the pavement, collection of litter, traffic management, repairs due to accident and all ancillary works including beautification. The periodic maintenance costs include cost of overlay, repair/renovation of road furniture, drains, buildings etc. The periodic maintenance includes periodic renewals at every 5 years.

Routine maintenance/ Periodic maintenance costs have been considered as per the MoRTH guidelines- "Report of the Committee on Norms for Maintenance of Roads in INDIA". The details of the maintenance costs and administration charges are given below in **Table 15.2**.

Expenses can broadly be classified based on the phases in which they are incurred,

- Toll collection expenses
- Administrative expenses for day-to-day operation
- Maintenance expenses, which include routine and periodic maintenance.

Interest expenses incurred for servicing term loans. Client would extend toll collection rights to the developer. The developer then would have the option of either collecting the toll himself or further subcontracting the same to a toll collection agency. In the present study, it is assumed that the developer would undertake operation and maintenance himself. The details of the toll collection expenses are given in the **Table 15.2**.

Table 15.2: Operation and Maintenance Cost (Year 2028-29)

S.No.	Description	Amount (Crores)
1	Routine maintenance in every year cost per km for four lanes with paved shoulder (Rs Crores / Km)	0.080 Crore / km /Annum
2	Periodic maintenance every sixth year cost per km for the two lanes with paved shoulder (Rs Crores / Km)	0.802 Crore / km / Annum
3	Toll Collection Exp.	2.29 Crore /Annum
4	Insurance @ Rs. 0.15% of TPC/annum	1.10 Crore /Annum

15.5 REVENUE ESTIMATION

The success of a BOT project depends on toll revenues covered w.r.t. project costs (construction, maintenance and administration). In order to calculate the Toll Rates and further Revenue, a detailed methodology has been worked out in context of Toll Notifications published from Year 2008 to Year 2014. The Notifications referred are as follows:

- National Highways Fee (Determination of Rates and Collection) Rules, 2008 (5th Dec).
- National Highways Fee (Determination of Rates and Collection) Amendment Rules, 2010 (3rd Dec).
- National Highways Fee (Determination of Rates and Collection) Amendment Rules, 2011 (12th Jan).
- National Highways Fee (Determination of Rates and Collection) Amendment Rules, 2013 (16th Dec).
- National Highways Fee (Determination of Rates and Collection) Amendment Rules, 2014 (16th Jan).

15.5.1 Toll Discounts

As per Toll Notification 2008 and amendments till date, it is stated that the users can avail various discounts on the applicable toll fee (Single Journey) by paying in the form of:

- **Multiple journey ticket** – 75% of single journey ticket (Maximum 2; one way journey allowed).
- **Monthly pass** – 66.67% of single journey ticket (Maximum 50; one way journey allowed).
- **Local non-commercial pass** – Rs 150/- pass for year 2007-08 subjected to annual revision for users residing within a distance of 20 km from the toll plaza location and vehicles registered for non-commercial purpose.
- **Local Commercial Discount** – 50% of single journey ticket for vehicles registered for commercial use without national permit. The vehicle must commute within the district of respective toll plaza and should be registered in the same district.

Considering all the discounts mentioned above, the split of various tollable categories has been calculated from the OD survey at km 10+000. The results thus obtained based on the vehicle registration number and trip length is mentioned below:

Table 15.3: Pass Policy (Discounts in Terms of %) at Km 10+000

Category of Traffic	Local (Non-Commercial & Commercial)	Single	Daily/ Multiple	Monthly
Passenger Car	10.25%	63.32%	17.62%	8.81%
Mini LCV	10.25%	63.32%	17.62%	8.81%
LCV's (4-Tyre & 6-Tyre)	8.77%	63.86%	18.25%	9.12%
Mini Bus	8.57%	67.21%	16.14%	8.07%
Standard Bus	8.57%	67.21%	16.14%	8.07%
2 Axle Truck	7.46%	67.09%	16.97%	8.48%
3 Axle Truck	7.58%	70.95%	14.32%	7.16%
MAV (4 to 6)	5.56%	82.15%	8.19%	4.10%
HCM/EME	0.00%	100.00%	0.00%	0.00%
OSV (7 or more)	0.00%	100.00%	0.00%	0.00%

15.5.2 Toll Rate Calculation

The Project investment would be recovered by imposing user levies on vehicles using the road. In general, the toll rate for the project should have a direct relation with the benefits that the road users would gain from its improvements. The benefits to road users are likely to be in terms of fuel savings, savings in travel time and Good riding quality.

As per National Highways Fee (Determination of Rates and Collection) Rules, 2008 & Amendment 2011, the user fee rates for 4-lane with paved shoulder for each category.

Table 15.4: Toll Rates in Year 2007-08

Toll Rates (Road)	Base rate of fee per km (in Rs.) Year 2007-08
Car, Jeep, Van or Light Motor Vehicle	0.65
Light Commercial Vehicle, Light Goods Vehicle or Mini Bus	1.05
Bus or Truck (Two Axles)	2.20
Three-axle commercial vehicles	2.40
Heavy Construction Machinery (HCM) or Earth Moving Equipment (EME) or Multi Axle Vehicle (MAV) (four to six axles)	3.45
Oversized Vehicles (seven or more axles)	4.20

Annual Revision of rate of fee: The annual revision of toll rates mentioned above shall be increased without compounding, by three per cent each year with effect from the 1st day of April, 2008 and such increased rate shall be deemed to be the base rate for the subsequent years.

The applicable base rates shall be revised annually with effect from April 1 each year to reflect the increase in wholesale price index between the week ending on January 6, 2007 and the wholesale price index for the month of December of the year in which such revision is undertaken but such revision shall be restricted to forty per cent of the increase in wholesale price index.

The applicable rate of fee shall be calculated as follows:

$$\text{Applicable rate of fee} = \text{base rate} + \text{base rate} \times \frac{\text{WPI A} - \text{WPI B}}{\text{WPI B}} \times 0.4$$

Where,

$$\text{WPI A (Dec 2024)} = 478.56 \text{ (155.7*1.873*1.641)}$$

$$\text{WPI B (06th Jan 2007)} = 208.7$$

The future inflation in WPI is considered as 5.0% for forecasting toll rates. The toll rates calculated for the year of opening traffic follows as:

Table 15.5: Toll Rates in Year 2025-26

Toll Rates (Road)	Base rate of fee per km (in Rs.) Year 2025-26
Car, Jeep, Van or Light Motor Vehicle	1.519
Light Commercial Vehicle, Light Goods Vehicle or Mini Bus	2.453

Toll Rates (Road)	Base rate of fee per km (in Rs.) Year 2025-26
Standard Bus or Truck (Two Axles)	5.140
Three-axle commercial vehicles	5.608
Heavy Construction Machinery (HCM) or Earth Moving Equipment (EME) or Multi Axle Vehicle (MAV) (four to six axles)	8.061
Oversized Vehicles (seven or more axles)	9.813

15.5.3 Toll Plaza Locations & Tolling Length

The project road has been section Kalavad to Jamnagar Ch. 0+000 to Ch. 47+572. The tolling length as per the toll notifications consists of length of highway, structures having length more than 60 m & bypass costing Rs 10 Cr. or more. As per the proposed project features the details are given below:

Table 15.6: Proposed Toll Plaza Locations and Effective Tolling Lengths

Toll Plaza Location Existing km	Length of Road (without structure) (km)	Length of Bypass (cost >10cr.) (km)	Length of Structures (>60 m) (km)	Total Tolling Length (km)
km 10+000	38.429	9.075	0.678	47.572

15.5.4 Toll Charges

The toll charges have been calculated as per National Highways Fee (Determination of Rates and Collection) Rules, 2008, Amendment 2010, Amendment 2011, Amendment 2013 & Amendment 2014. The estimated toll charges in year 2028-29 for the tolling section is as shown below:

Table 15.7: Toll Charges in Year 2028-29

Category of Traffic	Km 10+000
Passenger Car	105.00
Mini LCV	105.00
LCV's (4-Tyre & 6-Tyre)	165.00
Mini Bus	165.00
Standard Bus	350.00
2 Axle Truck	350.00
3 Axle Truck	380.00

Category of Traffic	Km 10+000
MAV (4 to 6)	550.00
HCM/EME	550.00
OSV (7 or more)	670.00

15.5.5 Traffic Details

The tollable traffic for the base year 2024 at proposed toll plaza location follows as:

Table 15.8: Tollable Traffic – Year 2024-25 (in No.)

Category of Traffic	Km 10+000
Passenger Car	3,182
Mini LCV	526
LCV's (4-Tyre & 6-Tyre)	343
Mini Bus	8
Standard Bus	190
2 Axle Truck	417
3 Axle Truck	148
MAV (4 to 6)	193
HCM/EME	7
OSV (7 or more)	0
Total Tollable Traffic	5,014

15.5.6 Traffic Growth

As per the current practice, 5% traffic growth is considered for all the categories for carrying financial analysis of the project highway.

15.5.7 Revenue Projections

The yearly revenue (in terms of crores) for a period of 20 years for the proposed toll location follows as:

Table 15.9: Yearly Toll Revenue

S. No.	From	To	Toll Revenue at Km 10+000 (Cr.)
1	1-Jun-28	31-Mar-29	25.80
2	1-Apr-29	31-Mar-30	34.34

S. No.	From	To	Toll Revenue at Km 10+000 (Cr.)
3	1-Apr-30	31-Mar-31	37.59
4	1-Apr-31	31-Mar-32	41.51
5	1-Apr-32	31-Mar-33	45.72
6	1-Apr-33	31-Mar-34	50.84
7	1-Apr-34	31-Mar-35	55.97
8	1-Apr-35	31-Mar-36	61.50
9	1-Apr-36	31-Mar-37	68.42
10	1-Apr-37	31-Mar-38	75.86
11	1-Apr-38	31-Mar-39	83.15
12	1-Apr-39	31-Mar-40	92.01
13	1-Apr-40	31-Mar-41	101.81
14	1-Apr-41	31-Mar-42	112.51
15	1-Apr-42	31-Mar-43	124.36
16	1-Apr-43	31-Mar-44	138.49
17	1-Apr-44	31-Mar-45	152.88
18	1-Apr-45	31-Mar-46	169.50
19	1-Apr-46	31-Mar-47	187.08
20	1-Apr-47	31-Mar-48	207.31
21	01-Apr-48	31-May-48	37.75
TOTAL REVENUE (in Cr.)			1904.40
NPV @ 12% Discounting (in Cr.)			-175.42

15.6 FINANCIAL MODEL INPUT AND ANALYSIS

The procedure and steps undertaken to assess the financial viability of the captioned project are outlined in this section. The first stage in evaluation of the financial viability is the identification of the revenue and expenditure streams. The revenue shall be generated primarily from toll income (details given in previous section).

15.6.1 Proposed Sources of Finance

In general, the developer shall crystallize the sources of finance by optimizing his equity returns keeping in view the project cash flows, terms, and conditions of various financing options available. Further the market standing and financial strength of the Developer would largely determine the terms and conditions of finance offered to the Developer by various lending

agencies. For the purpose of the study, following sources of finance have been taken:

- Equity: To be provided by the Developer.
- Subsidy / Grant for viability of funding, to be provided by the client.
- Debt: To be arranged by the Developer / Concessionaire.

15.6.2 Resource Mobilization Schedule

In general, the duration of construction for similar size road projects ranges between 2.0-2.5 years. The project implementation period has been taken as 24 months. Based on the implementation period, the project cost has been phased as under:

Table 15.10: Project Cost Phasing

Description	1 st year	2 nd year
Progress of Work & Cost Phasing	60%	40%

15.6.3 Minimum Return Criteria

The minimum return criterion for the B.O.T project is considered as follows:

Return on Equity (Equity IRR): Considering a safe investment in bank in the form of a term deposit, an interest rate of 10% is generally a return with safety. However, when investing in the road sector, a perspective investor would normally need to cover the business risks (e.g. the decreasing revenue, increasing cost, construction time overrun, etc.) and therefore would require a return higher than a return on the safe investment as mentioned above. Based on usual trends, it is estimated that an additional return of 5% would be adequate to cover these risks. Hence, a minimum return on equity of 15% could be considered satisfying the requirement of prospective concessionaire.

The minimum average DSCR is taken as 1.0 to 2.0.

Considerations for Calculating the Project IRR

- * Investment = Net Project Cost
- = Total Project Cost–Equity Support (Grant during Construction)
- * Operating Income = Toll Revenue - O&M Support
- * Operating Expenses = Toll Plaza Maintenance
- Annual Maintenance of Road
- Periodic Maintenance of Road

Concession Fee

Tax on Net Profit as per Income Tax Act

Interest on Debt/Loan (Diminishing Interest)

Debt/Loan Repayment

Considerations for Calculating the Equity IRR

- * Investment = Equity Contribution on Net Project Cost
(30% of the Net Project Cost by the Concessionaire)
- * Operating Income = Toll Revenue, O&M Support (Grant during Operation)
- * Operating Expenses = Toll Plaza Maintenance
Annual Maintenance of Road
Periodic Maintenance of Road
Concession Fee
Tax on Net Profit as per Income Tax Act
Interest on Debt/Loan (Diminishing Interest)
Debt/Loan Repayment

Debt Service Coverage Ratio (DSCR)

- * DSCR = $\frac{\text{Net Operating Income}}{(\text{Interest on Loan} + \text{Repayment of Loan} + \text{Tax})}$
- * Net Operating Income = Total Revenue – O&M Expenses

Net Operating Income Period equal to Loan Repayment Period.

15.6.4 Tax Calculation Module

According to the scheme under section 80-IA, 100% of the profit is deductible for the continuous period of ten years out of the concession period. However, the benefit deduction is available only for ten consecutive assessment years falling within the concession period. The tax rate adopted for this study is 34.32% following the deduction of depreciation and amortization. Minimum Alternate Tax (MAT) of 17.47% has been taken into account for the total concession period.

15.6.5 Financial Viability

The main objective of undertaking this study is to assess whether the project is financially viable or not. It is important to note that the proposal should be an attractive proposition for

private sector participation under Build, Operate and Transfer (BOT) system. The basic methodology followed for estimating the financial viability of the project is to calculate the FIRR (Financial Internal Rate of Return) on the investment for the project.

Following assumptions are taken into consideration for the financial analysis:

- Debt – Equity ratio: - 70:30.
- Grant – 40%.
- Concession period (Including 730 days construction period) – 22 years.
- Escalation – 5%.
- Interest on Debt – 11.5%.
- Loan Repayment period – 11 years.
- Tax rebate – 10 years (100% exemption for 10 years out of block of 20 years).
- Depreciation by Straight line method – 100% for Concession Period.

15.7 RESULTS

Based on the project structure traffic study and toll rate analysis, financial feasibility analysis has been carried out as per the methodology outlined in earlier sections. The objective of the financial analysis is to ascertain the existence of sustainable project returns, which shall successfully meet the expectations of its financial investors. The analysis reveals various FIRR values corresponding to each year of toll operation. FIRR for the Returns on Investment and Returns on Equity for the concession period of 22 years has been examined. The results are given below in **Table 15.11**.

Table 15.11: Sensitivity for the FIRR

S. No.	Scenario	Grant	Project IRR (%)	Equity IRR (%)
1	5% Growth Scenario	40%	7.60%	4.54%

15.8 CONCLUSIONS

The financial analysis of the project road has been carried out for a period of 22 years for 5% growth scenario. The base year toll able traffic is 5,014 nos. at km 10+000.

The viability of the project has been examined for grant allocation of 40%. For the given set of conditions, the Equity IRR comes to be 4.54% as against 15% (viability), whereas the DSCR comes to be 0.71, as against minimum 1.0. Therefore, the project is found to be financially Non-viable on BOT (Toll) basis and recommended on EPC/HAM mode.



CHAPTER - 16
ACCIDENT ANALYSIS
AND ROAD SAFETY PLAN

CHAPTER - 16

ACCIDENT ANALYSIS AND ROAD SAFETY PLAN

16.1 INTRODUCTION

The problems of accident on Indian roads are very acute due to complex flow of vehicular traffic, presence of mixed traffic and lack of knowledge of traffic rules. A traffic accident involves property damages, vehicle damage, personal damages, personal injuries or even casualties. Road accidents cannot be totally prevented, but by suitable engineering measures, the accident rate can be decreased considerably.

It is essential to analyze every individual accident and to maintain road section wise accident records. The statistical analysis of accidents carried out periodically at critical locations or road stretches or sections will help to arrive at suitable measures to effectively decrease the accident rates. The various objectives of the accident studies are as follows:

1. To study the cause of accidents and to suggest corrective treatment at accident potential locations.
2. To identify and locate black-spot on road.
3. To evaluate existing designs.
4. To carry out before and after studies and to demonstrate the improvement in the problem.
5. To work out the solution & suggestion to minimize the accidents.

16.1.1 Road Accident Scenario

An accident is defined as an unplanned and uncontrolled event in which action and reaction of an object or person results in personal injury or damage to the property. A traffic accident may be taken as failure of the road-vehicle-driver system to perform one or more operations necessary for completing a trip without any injury or loss. Road accidents are mainly due to insufficient maintenance of the road network and lack of efficient and systematic enforcement. Necessary and sufficient cause of an accident is a combination of simultaneous and sequential factors, each of which is necessary but none of which is by itself sufficient. Road accidents were associated with numerous problems each of which needed to be addressed separately. Human, vehicle and environment factors play roles before, during and after the trauma event. The road accident scene in India as in many developing countries is characterized by mixed traffic comprising human powered vehicles such as bicycles, tricycles, animal-drawn carts, and motor vehicles of various sizes, shapes and speeds, without adopting traffic segregation measures.

16.1.2 Need of Crash Analysis

A Crash is defined as any incident and resulting injury resulted from a combination of factors related to the components of the environment-equipment/ machine/ vehicle user system and to the way they interact. Crashes occur because of various factors including the driver, vehicle, roadway, and environment. Some factors contribute to the occurrence of an Incident and are therefore part of incident causation. Other factors aggravate the effects of the incident and thus contribute to trauma severity some causes are immediate, but they may be underpinned by medium and long term structural causes. Identifying the risk factors that contribute to injuries is important in identifying interventions that can reduce the risk associated with those factors.

The primary source of crash data is the local enforcement agencies. Crash data are used to help understand why crashes occur, to help identify high-crash locations, to aid in the choice of safety programs or countermeasures, and to assist evaluations of countermeasure effectiveness. The main purpose of crash analysis is to improve safety by identifying crash patterns, mitigating crash severity, and reducing the number of crashes by adopting suitable countermeasures.

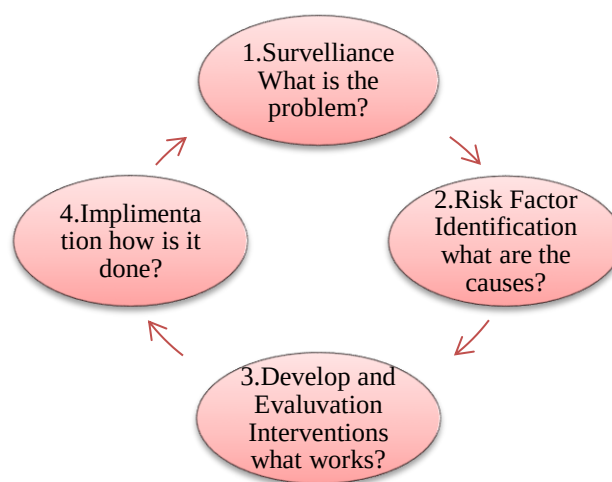


Figure 16.1: Accident Analysis Flow Chart

The first step is to determine the problem due to which accidents are occurring. This step includes obtaining information on the demographic characteristics of the person involved, the temporal and geographical features of the incident, the circumstances under which it occurred, and the severity and cost of the injures. The second step is to identify the factors that increase the risk of injury of disability, and to determine which factors are potentially modifiable. The second step looks at “why” the accident happened. It may also be used to define populations at high-risk for violence or accidental injuries and to suggest specific interventions. The third step is to assess what measures can be taken to prevent the problem by using the information about causes and risk factors to design, pilot test and evaluate

interventions. The final step is the implementation of interventions that are highly likely to be effective on a broad scale. In both instances it is important that data be collected to evaluate the program's effectiveness.

16.1.3 Methodology

- ❖ Collection of Data.
- ❖ Data compilation and preparation of database as per IRC code 53-2012.
- ❖ Analysis of Data.

16.1.4 Data Analysis

The Project study corridor starts from Existing Km 50+925 of SH-26 (old) near Kalavad town and ends at ends at Jamnagar: Existing km 3+720 of SH-26(old). Total proposed length of project road is 47.572 km .The start point of the project road is the junction of Kalavad town along SH-26 and end point is at starting of Jamnagar. Present section of the Report comprises of accident analysis of existing alignment. Accident data has been collected from various police stations along the existing alignment and findings of the same is presented in this chapter. Police stations from where accident data has been collected are given in **Table 16.1:**

Table 16.1: Details of District Wise Police Stations

S. No.	District	Police Stations
1	Jamnagar	Kalavad
2	Jamnagar	Panch Koshi Division

Accident analysis has been done in two sections covering project road passing through Jamnagar and Rajkot districts. District wise Accident analysis has been done as per IRC: 53-2012. For the analysis of accidents last five years data has been collected. Analysis is carried out to identify deficiencies in alignments, pavement widths, shoulders, lighting, road marking, drainage, and caution/sign boards etc., causing fatal accidents. Following points indicate a sample of kind of data collected, analyzed and classified for the Project road as per IRC: 53-2012.

- ❖ Identification particulars (Place/ district/police station/FIR no. etc.)
- ❖ Locations (e.g. NH/ SH/ km/ urban/ non-urban/ intersection/ school/ Market).
- ❖ Date, day and time (time/day of week/Holiday/special day etc.).
- ❖ Weather conditions (Dry/hot/rainy/fog etc.).
- ❖ Classification of accident (Fatal, Grievous, minor).
- ❖ Type of Vehicles and objects involved.

- ❖ Nature of the Accident (overturning/ Collisions, Head on, Rear end, Side swipe, skidding, right turn etc.).
- ❖ Responsibility of driver (Exceeded speed limit/ consumed alcohol/ jumped signal/ fatigue etc.).
- ❖ Details of pedestrian or person other than the Driver involved in Accident.
- ❖ Type of persons and animals killed or injured.
- ❖ Type of damage to vehicles and property.
- ❖ Road features (single lane/2-lane/4-lane/service road present or not/footpaths and cycle track present or not).
- ❖ Intersection type and control (no control/signal/police control/ any other).
- ❖ Name of persons killed/ grievous injuries whether pedestrian/driver, etc.).
- ❖ Cause of Accident (whose fault drivers/ pedestrian/ two-wheeler driver etc.).

16.1.4.1 Analysis of Jamnagar District

Following section comprises of Panch Koshi, Kalavad police stations which covers the area of project road form Km 4+700 to Km 72+500. Analysis and interpretations of accidents has been discussed below. Interpretation has been represented as following:

❖ Yearly Accident Occurrence

Following graph shows yearly trend of accidents where maximum number of accidents were in year 2013 which finally declined in year 2014.

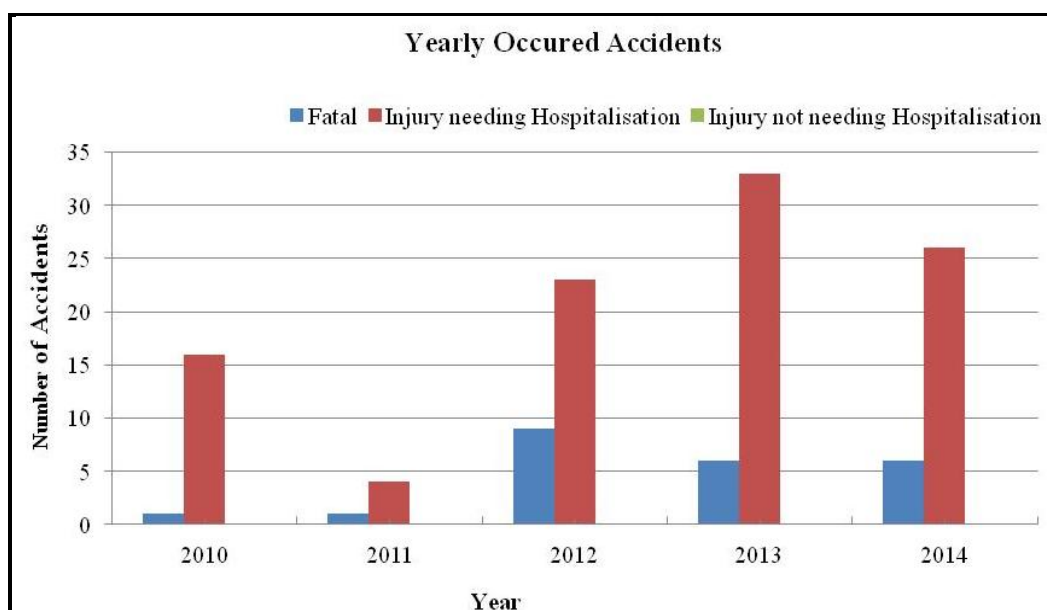


Figure 16.2: Jamnagar District Yearly Accident Trends

❖ Accident Details hourly basis

The graphs show most of the accidents has occurred in day time from 9:00 to 17:00 hours. In night time since vehicular movement is less as seen in traffic classified volume count hence major accidents have occurred during day time.

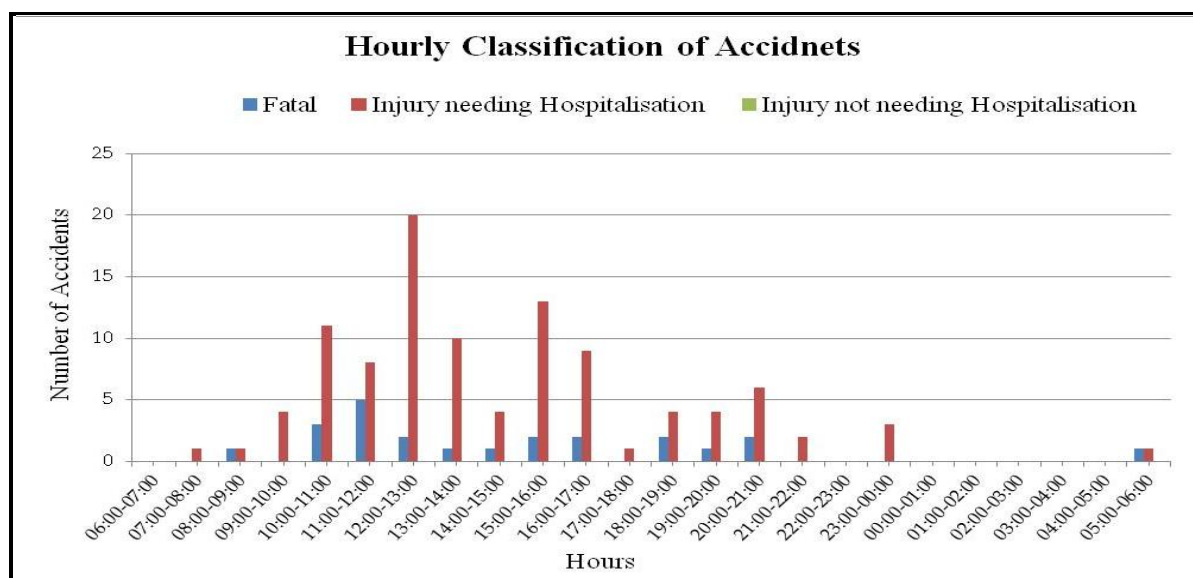


Figure 16.3: Jamnagar District Hourly Accident Trend

❖ Accident Classification According to Type of Collisions

The pie chart shows that 74% of accidents were caused due to head on collision followed by 16% caused hitting pedestrians.

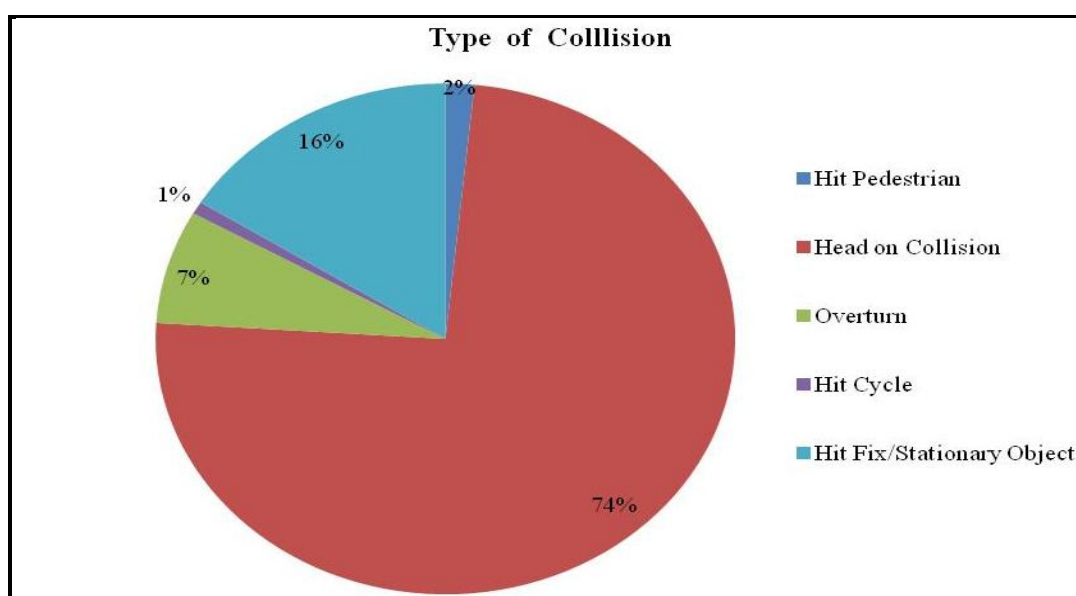


Figure 16.4: Jamnagar District Accident Classification According to Type of Collision

❖ Accident classification according to sex of victims

Mostly accidents victim were male and only 5% of female victims were recorded.

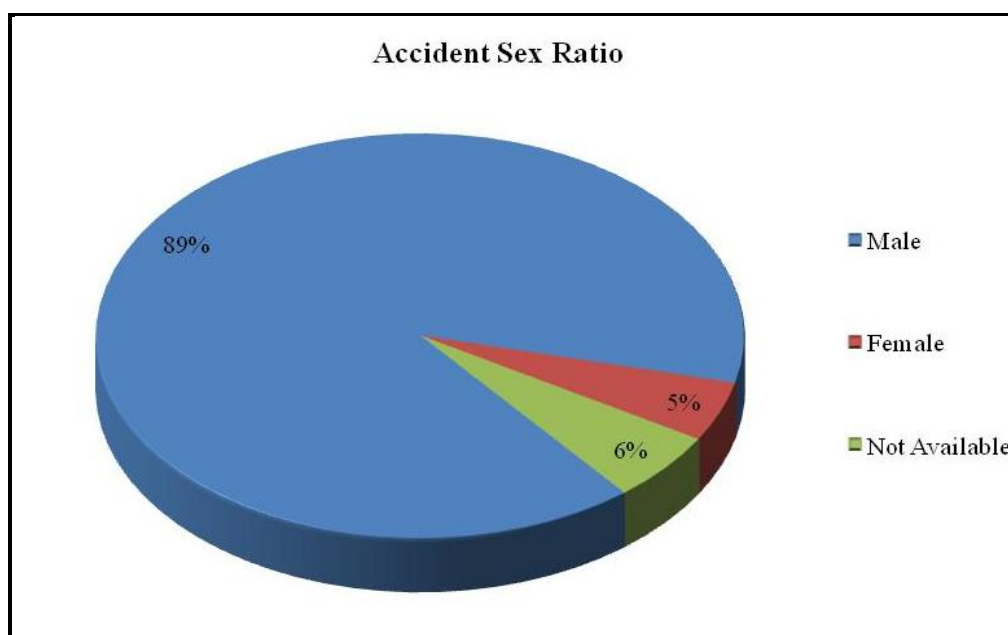


Figure 16.5: Jamnagar District Classification of Victim According to Sex

❖ Accident Classification by Nature of Traffic Violation

The following graph represents accident crashes have occurred due to over speeding of vehicles on road.

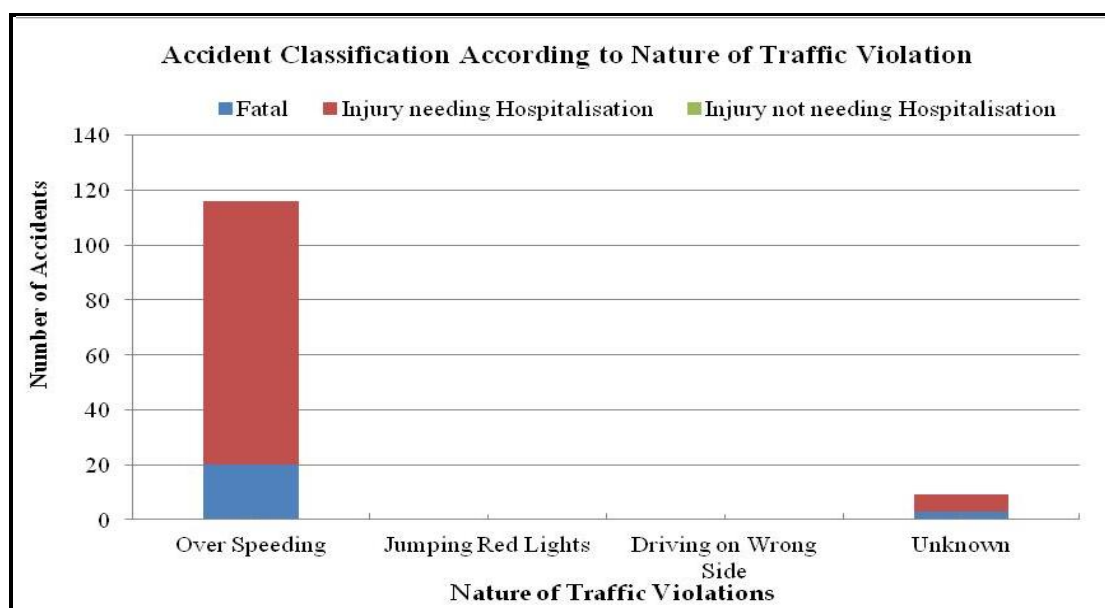


Figure 16.6: Jamnagar District Classification of Accident by Nature of Traffic Violation

❖ Accident classification according to type of vehicle involved

Graph represents mostly motorized two wheeler vehicles were responsible for road accidents followed by car and light trucks.

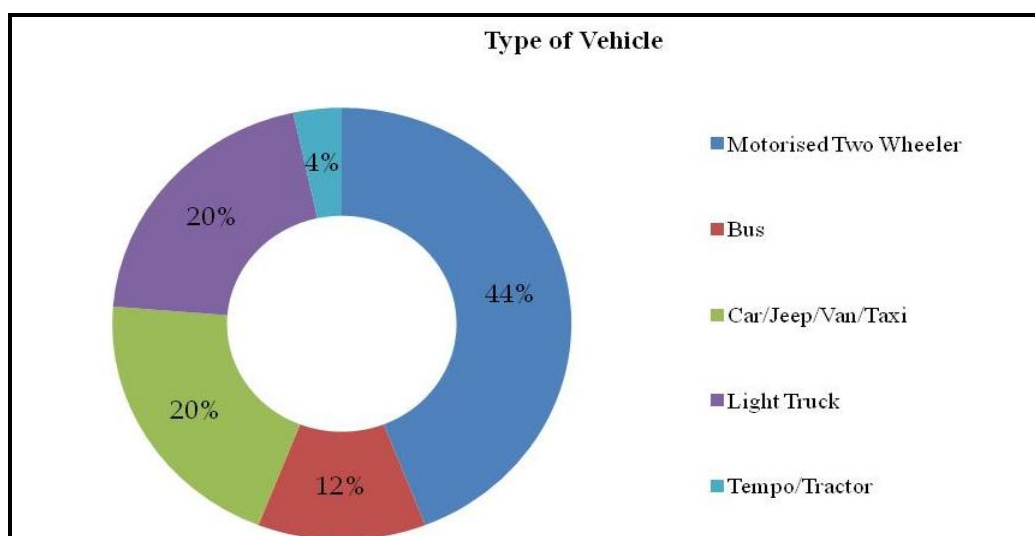


Figure 16.7: Jamnagar District Type of Vehicles Involved In Accident

❖ Location Wise Accident Details

This graph shows locations nearby where accidents have taken place; it shows maximum number of accidents have occurred in Theba village, Vijarkhi Village and Madhapar Village. These are generally locations of junctions which connects project road with villages hence inadequate junction deficiency could be the reason of accidents taking place in these locations.

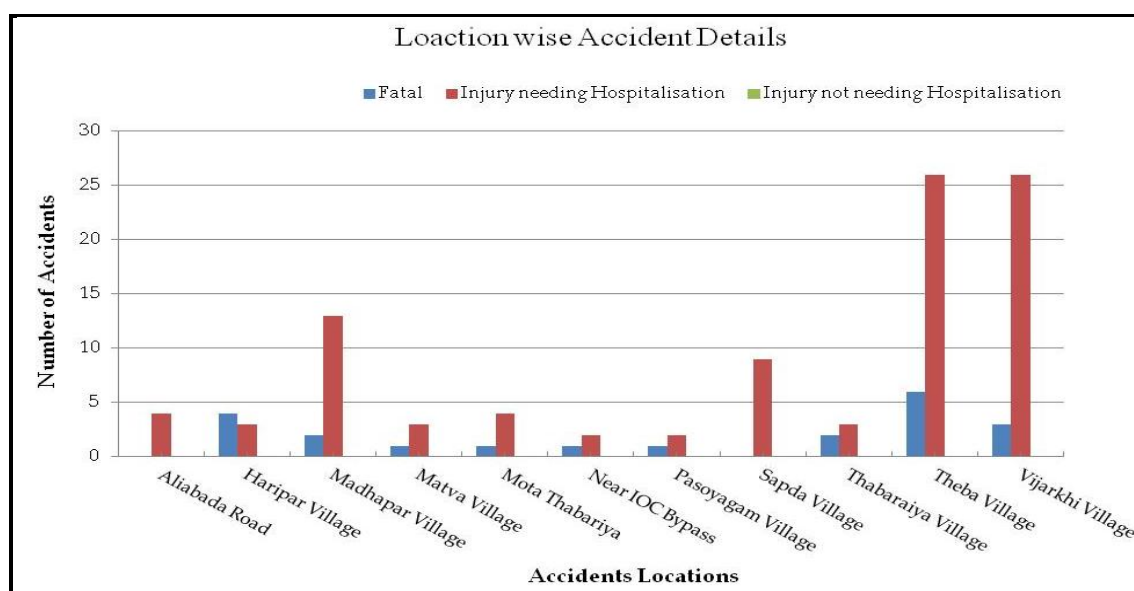


Figure 16.8: Jamnagar District Location Wise Detail of Accidents

Table 16.2: Accident Locations in Jamnagar District

Accident Location	Chainage
Theba Village	6+300
Vijarkhi Village	12+000
Madhapar Village	60+800

❖ **Accident severity index (ASI) and weighted severity index (WASI)**

The **accident severity index** measures the seriousness of an accident. In order to quantify the criticality of an accident site, a system of assigning scores has been adopted based on severity of accident. It is defined as the number of person killed per 100 accidents which contains all type of accidents. The value of ASI is dimensionless because it is ratio of quantities of similar units. **Table 16.3** represents the calculated ASI year wise.

Table 16.3: Jamnagar District Yearly Accident Severity Index

Year	ASI
2010	6
2011	20
2012	28
2013	15
2014	19

ASI value depends upon the number of fatal accidents taking place therefore, graphically it shows that ASI index keeps on increasing from 2010 and reached to highest value in last 5 years and then declines in year 2013 and 2014.

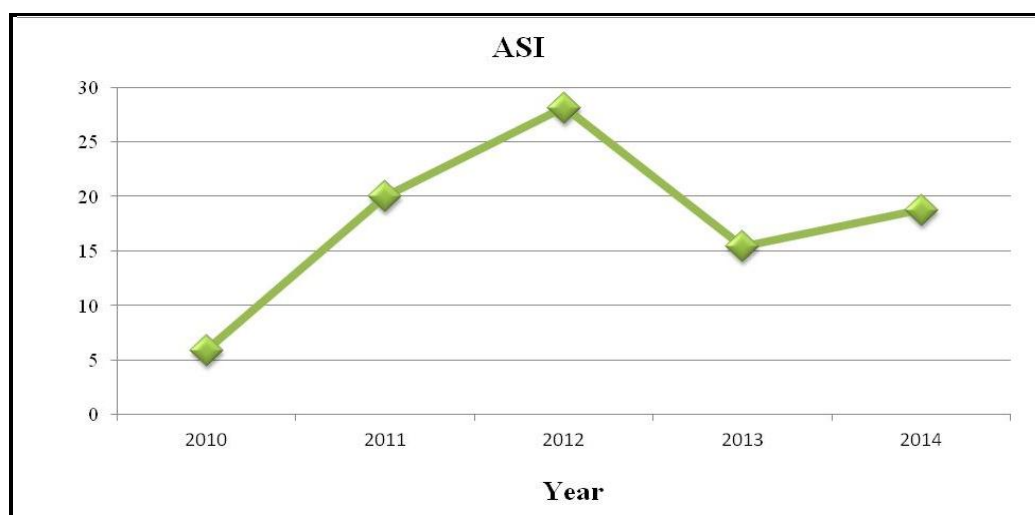


Figure 16.9: Jamnagar District Accident Severity Index Graph

Weighted Accident Severity Index–In Weighted accident severity index weightage is given to each accident on the basis of scale 1 to 5 on the basis of type of accident as follows:

Table 16.4: Jamnagar District Weighted Accident Severity Index Scale

Accident Type	Scale Index
Fatal	5
Very Serious	4
Grievous	3
Minor injury	2
Non injured	1

The equation used for finding accident severity index (WASI) is:

$$\text{WASI} = (A*5+B*4+C*3+D*2+E*1)/X$$

Where,

A = Total Fatal accidents

B = Total very serious accidents

C = Total grievous accidents

D = Total minor injuries

E = Total non-injured

X = Total Accidents

From the above formula WASI has been calculated and yearly calculated values are given in **Table 16.5.**

Table 16.5: Jamnagar District Weighted Accident Severity Index

Year	WASI
2010	3.12
2011	3.40
2012	3.56
2013	3.31
2014	3.38

Figure 16.10 Graph shows there is not much deviation in WASI values in last five years.

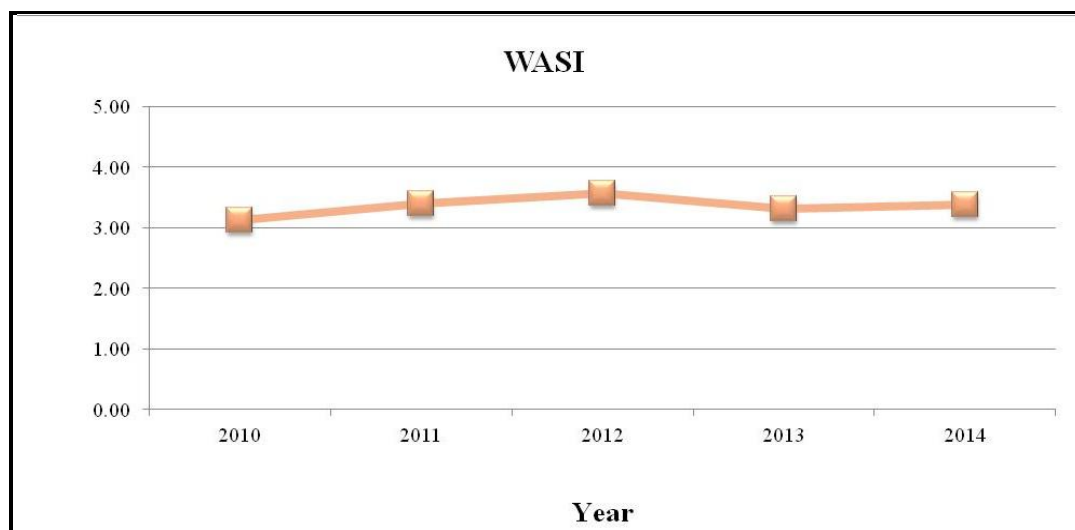


Figure 16.10: Jamnagar District Weighted Accident Severity Index Graph

16.1.5 Conclusion

Based on the five years accident investigation data for Dhoraji - Jamnagar Project, this study concludes the following:

1. On project road from 4+700 to Km 72+500 maximum accidents have occurred in year 2012, total 65 accidents were recorded consisting 12 % fatal accidents and 88% minor accidents causing injuries.
2. It is observed accidents have been occurred during the day time from 8:00 to 20:00 hours.
3. Type of accidents seen as Head on collisions, overturning, and hitting pedestrians. Reasons analyzed due to road configuration at accident location, lack of safety warning signage's, speed limit signage's.
4. Analysis shows that majority of accidents occurred due to over speeding of vehicles and driving vehicle on wrong side.
5. Majority of accidents involved for two wheelers followed by cars and light trucks.

Vehicles Involved	From Km 4+700 to Km 72+500 (% of vehicles)
Motorized Two Wheeler	40
Car/Jeep/Van/Taxi	20
Light Truck	20

6. From Km 4+700 to Km 72+500 Accident severity index graph depicts in year 2012 value is highest and it falls gradually and remains more or less constant in year 2013 to 2014.
7. Weighted Accident Severity Index graph shows that there is constant value occurred in last five years in both sections. WASI index value depends upon number of accidents occurring in particular period; here in this case it is yearly. Hence it concludes that yearly numbers of accidents taking place are more or less same.

16.2 ROAD SAFETY MEASURES

Various considerations made for the safe design and the safety features included are summarized under following subheadings:

1. General
2. Alignment
3. Grade Separated Interchange
4. Intersection Arrangements, Underpasses
5. Non-motorized User Provision
6. Road Signs, Pavement Marking & Lightings
7. Roadside Hazard
8. Roadside Communities & Facilities

It may be worth mentioning that the National Highway is designed not as fully access controlled, and it will have interaction with local traffic, slow moving vehicles and other vulnerable road users. The safety measures proposed for the NH are explained in the following subsections.

16.2.1 General

The cross sectional parameters such as width of lane, shoulder and median, and side slope also have been examined which have direct bearing with safety of the NH. The project highway having low traffic and although it is not satisfies the requirement of upgradation. But as per MoRTH guide line Two lane with paved shoulder has been proposed in place of Existing Intermediate Lane or Two lane only. The Urban area of Jamkandorna and Kalavad are existing four lane configuration having Deficient Geometry. This section proposed with improved geometry and divider by New Jersey Barrier. Direct access to the highway has been controlled by traffic calming measures on side road and developed Junction as per IRC guide line.

16.2.2 Alignment

The horizontal and vertical alignments have been designed by improved Geometry at Deficient locations. There are many deficient curves where improvement has been proposed in alignment plan. Realignment and Bypass has been proposed where deficient geometry has been found at Kalavad, Haripar, Khandera, Vijarkhi Village. All curves have been provided with adequate transition and super elevation. The obstruction to sightlines by safety fences and other street furniture also have been verified.

16.2.3 At-grade Intersections

Except the flyovers and VUP, traffic will be transferred through at-grade intersection arrangements where direct conflicts between turning vehicles will take place. All at-grade intersections are as per IRC guide line and Traffic safety signage's and speed breakers and other safety features. Being at-grade junctions, there will be conflicts between moving traffic and other vulnerable road users. However being a low traffic there is no such conflicts but considering safety for a single vehicle measures shall be provided.

Non-motorized User Provision

All vulnerable road users like pedestrians and cyclists have been segregated from the exposure of fast-moving traffic in built up areas by Four lane configuration and additional Paved block and carriage way width.

16.2.4 Road Signs, Pavement Marking & Lighting

For Grade separator and other at-grade intersections, shoulder and gantry mounted advanced directions signs will be provided. The font size of these direction signs will be chosen appropriate for the approach speed of NH and destinations will be given in two languages. The English lettering shall be with "Transport Medium" font. The signs shall be with retro reflective sheeting of micro prismatic grade conforming to ASTM standards for medium and long distance visibility. All curves have been properly delineated with single chevrons signs and will be placed on outer edge of the curve, on approach and on curve so as to view at least 2-3 chevrons at a given instance of viewing.

Pavement markings will be done for traffic lane line, edge lines and hatching. The marking will be with hot applied thermoplastics materials. Highway lightings including high masts will be provided at critical reaches in order to improve the night time visibility.

16.2.5 Roadside Hazards

Road restrain systems will be provided to protect the road users from roadside hazard like signs, gantries, and abutments. Metal beam crash barrier will be provided at the outer edge of all curves and for steep embankments exceeding 3m height and for water hazard having at least 1 m water stagnation to contain and deflect any errant vehicles. The metal beam crash barrier coming on either side of the approach will be continued with rigid beam crash barrier provided for the structure to maintain the continuity. All structure parapets and roadside hazard will be illuminated with hazard markers to help an approaching driver to judge the structure/ hazard locations. In order to help the road users to better align the curves, delineator posts will be provided on outer edge of the curves.

16.2.6 Roadside Communities & Facilities

Wherever NH passes through inhabited area, special treatments will be required. Gateway effect will be created with footpaths, speed limit signs and road humps to clam for the approaching traffic. Pedestrian crossing will be provided to safely accommodate pedestrians and will be streamlined through pedestrian railing.

16.3 TRAFFIC MANAGEMENT DURING CONSTRUCTION

Traffic movements within work zone will be carried out by reflective traffic cones, barricades and delineators and directional signs and pavement markings as per IRC: SP:55. Careful consideration shall be exercised by the supervising engineer to ensure that that these arrangements will cause minimum inconvenience to traffic, however ensuring safe maneuvering for vehicles through the work zones shall be top most priority in the traffic management of work zones. The traffic control devices shall be inspected regularly to ensure to its positioning as the work advances and shall be maintained. The traffic management plans for different construction scenarios are given in **below figures**:

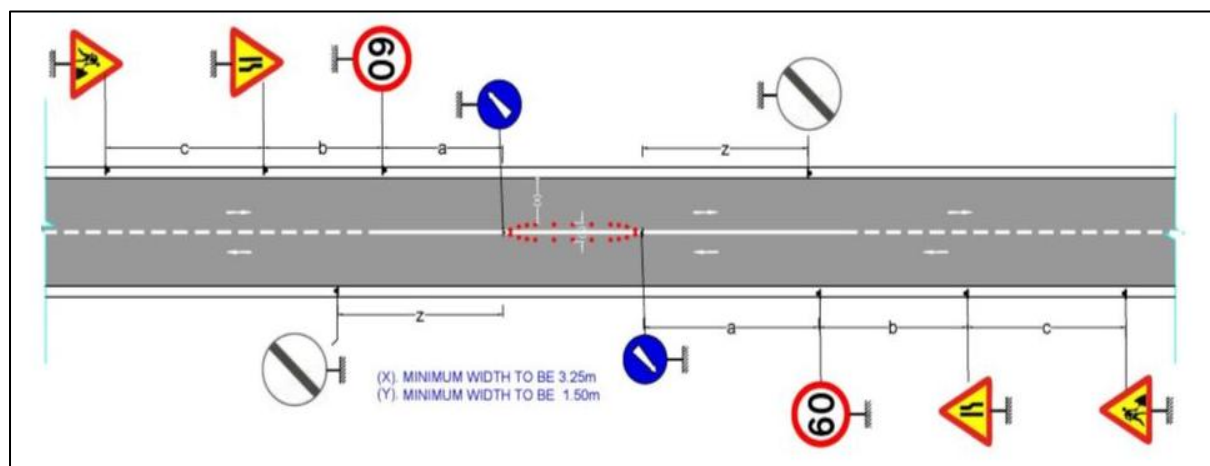


Figure 16.11: Work at Center of Carriageway

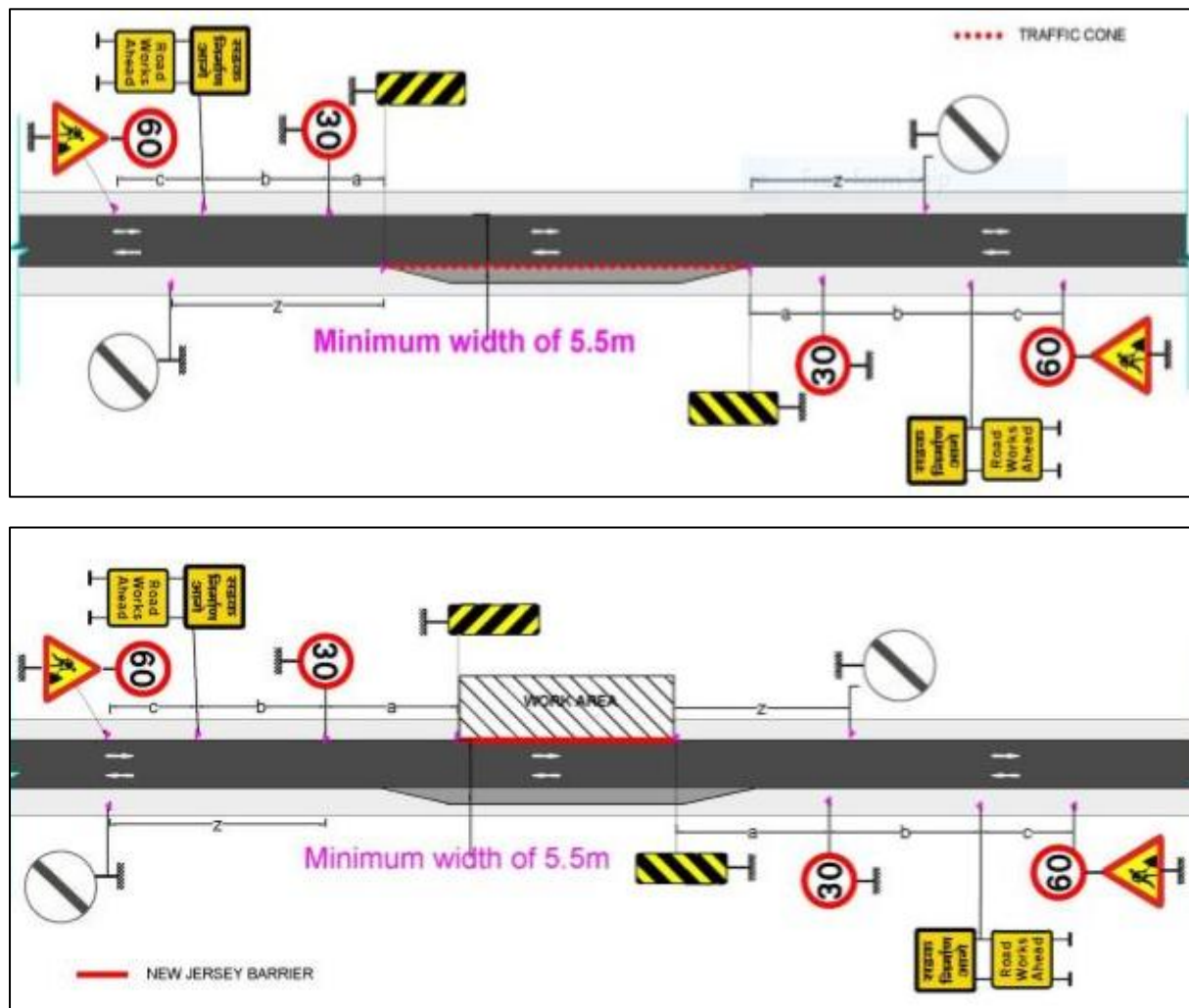


Figure 16.12: Stage-1 Intermediate Lane Road into 2-Lane with Shoulders

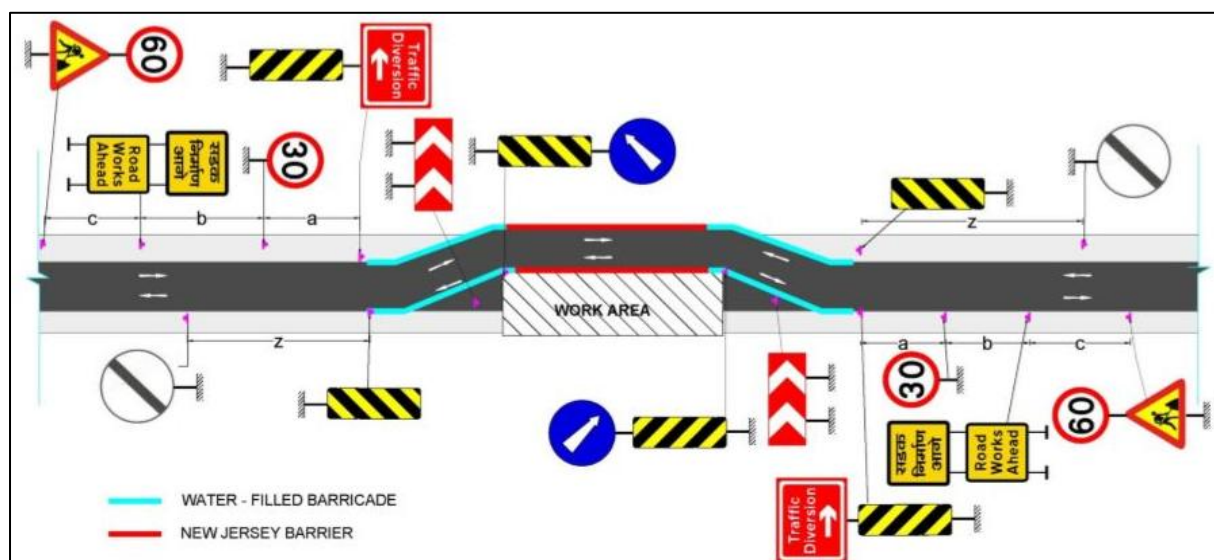


Figure 16.13: Stage-2 of Intermediate Lane Road into 2-Lane with Shoulders

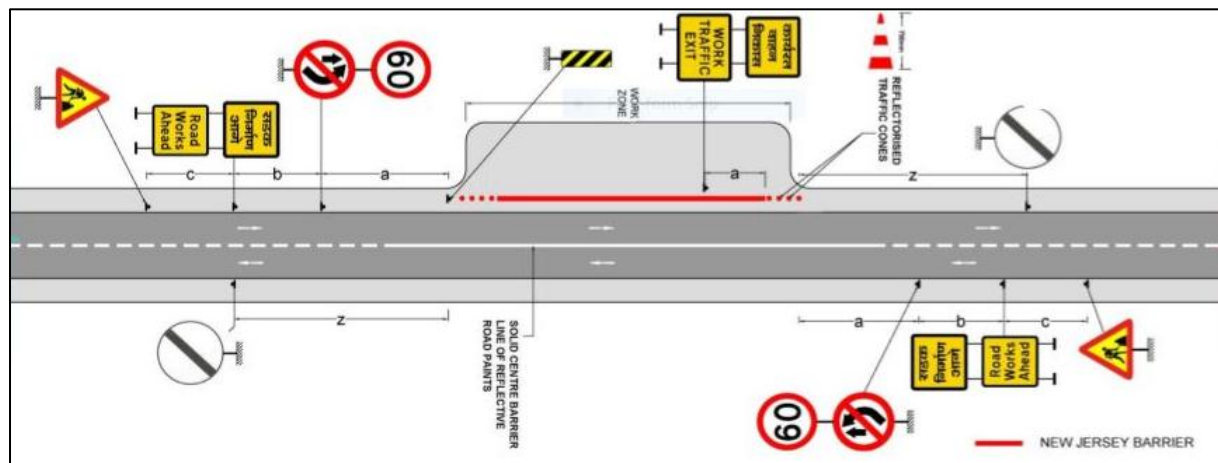


Figure 16.14: Lateral Widening

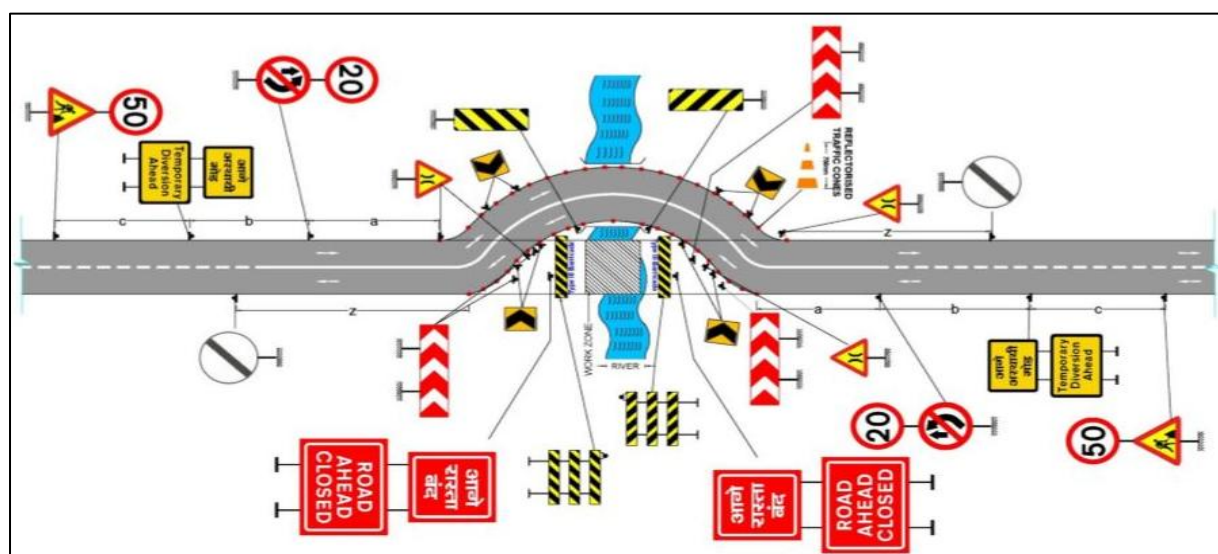


Figure 16.15: Temporary Diversion for Reconstruction of CD Works

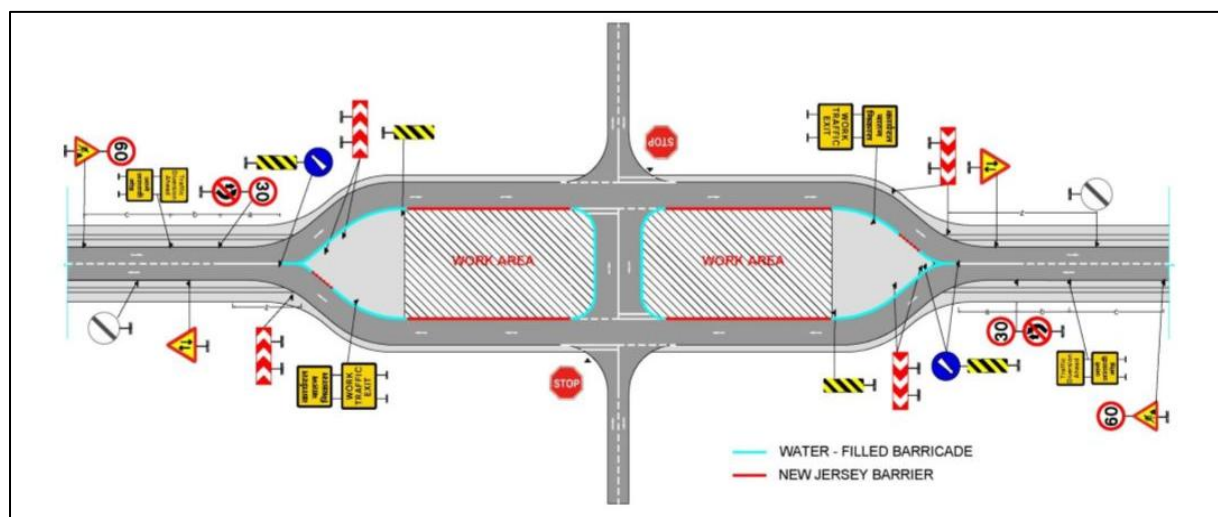


Figure 16.16: Stage-1 of Flyover/ VUP Construction

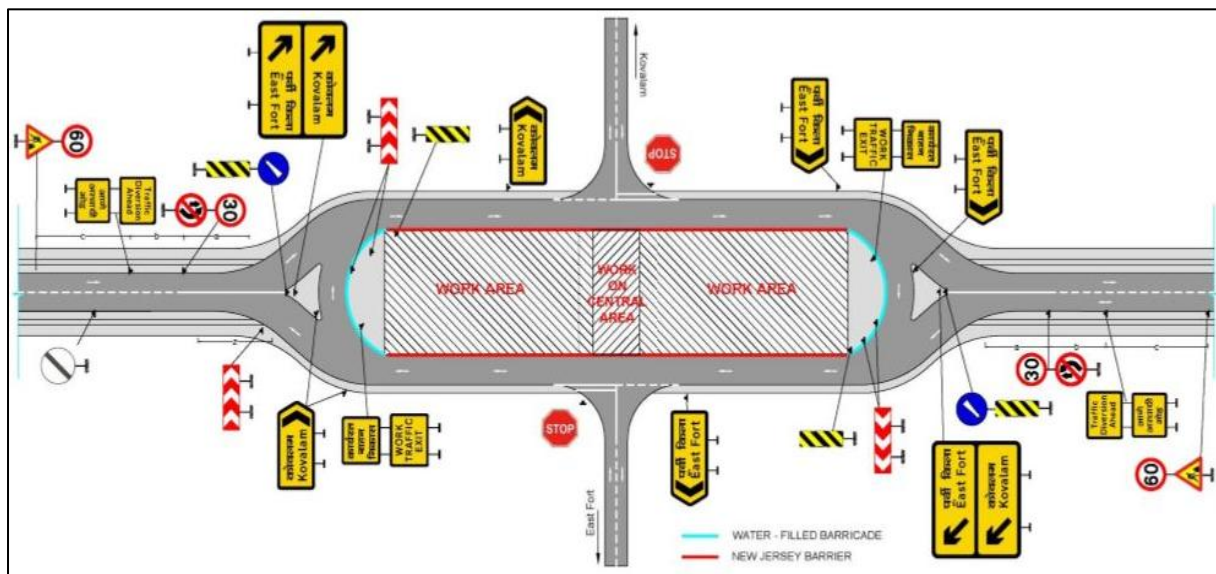


Figure 16.17: Stage-2 of Flyover/ VUP Construction

16.4 CONCLUSION

Various safety elements considered in the geometric design of the NH and the road safety features incorporated in the report will address the safety engineering aspect of the national highway. During construction, the layouts proposed for various construction scenarios shall be strictly adhered as per IRC: SP:55. The road safety features will be installed in such a way to make it as a “forgiving highway”.

□□□

CHAPTER - 17

CONCLUSION AND RECOMMENDATION

CHAPTER - 17

CONCLUSION AND RECOMMENDATION

17.1 RECOMMENDATIONS

17.1.1 Based on the Lane Capacity

Presently the project corridor carries the traffic plying 10766 PCU for section between Jamnagar to Kalavad. As per Ministry circular dated 26.05.2016, It has been decided to take up the project stretch where traffic exceed 10000 PCU, shall be eligible for four lane configurations. Accordingly the project corridor from Jamnagar to Kalavad is recommended for taken up for four lane configuration. A four-lane bypass for Kalavad town has been recommended considering traffic moving towards Rajkot will use Kalavad Bypass because dense habitation and deficient geometry. Accordingly, four lane Kalavad bypass with concentric widening in 60m ROW has been proposed. The design length of Package-2 project stretches comes out 47.572 km.

Proposed Geometric improvement/realignments

The project stretch comprises various geometric deficient stretch having 66 no. locations. These deficiencies are improved for 100 kmph Design speed with realignments at Haripar, Khandera, Vijarkhi at 100 kmph Design speed. To improve existing stretch into four lane configuration with above improvements approx. 135.441 ha. land acquisition shall be required

17.1.2 Proposed structures

The proposed cross drainage structure for project highway is 5 Nos. of Major Bridge, 16 Nos. of Minor Bridge, Main carriageway have been proposed for reconstruction (10 no.) and new construction for 4 no. and two minor bridges on service road, 77 no. Culverts along the proposed alignment of the road.

17.1.3 Summary of Existing and Proposed Features

Table 17.1: Summary of Existing and Proposed Features

S. No.	Descriptions	Existing Features	Proposed Features	Remarks
1	ROW	From Km 50+925 to 3+720 = 24.0m	PROW in Brownfield= 30m PROW in Greenfield and Realignments = 45 m PROW at Toll Plaza = 70m.	Approx. 98 Ha. Land acquisition will be required

S. No.	Descriptions	Existing Features	Proposed Features	Remarks
			PROW at Bus Bay and Truck Lay Bye = 40m	
2	Carriageway Width (m)	Project Road Configuration is Intermediate Lane (6.10 m) to 2-lane except 2.2 km length of 4-lane configuration 3.500 km length in Kalavad.	4-lane configurations from Ch 0.000 to 47.572 (length 47.572 km)	4-lane configuration has been proposed throughout the length.
3	Bridges	Major Bridges – 2 Nos. Minor Bridges – 16 Nos.	Major Bridges – 05 Nos. Minor Bridges – 16 Nos.	Major Bridges: a) New (03 Nos.) b) Existing Minor bridges reconstructed (02 Nos.) Minor Bridges: a) New (05 Nos.) b) Reconstruction (9 Nos.) c) New on Service Road (02 Nos.)
4	Culverts	73 Nos.	77 Nos.	Reconstruction - (58 Nos.) New (19 Nos.)
5	Major Junctions	4 Nos.	5 Nos.	Major Junctions increased due to Bypass.
6	Bypass	Nil	Kalavad- 9430m Length	Total Bypass length is 9.430 km
7	Realignments	Nil	1. Haripar-1400m Length 2. Khandera -1373 m Length 3. Vijarkhi- 1970m Length	Total Realignments length is 4.743 km
8	Rest Area	Nil	Nil	Nil
9	Truck Lay Bye	Nil	2 Nos.	Ch 10.517 RHS & Ch 43.982 LHS
10	Bus Stops/Bus Bays	16	26 Nos. (Including Both Side)	Shelter Type Bus stop-12 (Both Side) Bus Bays -14 (Both Side)

S. No.	Descriptions	Existing Features	Proposed Features	Remarks
11	Drain	Earthen Drain in Few Stretches along the alignment.	Total Length of Drain - RCC Lined Drain- 16.598 Km - Trapezoidal Lined Drain- 4.370 Km - Earthen Drain – 26.020 km - RCC Lined Drain with Retaining wall- 48.156 Km	There is no Existing Line drain along the project stretch
12	Cattle Underpass	Nil	Nil	Nil
13	Vehicular Underpass	Nil	VUP-3	Ch 1.216, Ch 4.600 & Ch 8.255 (VUP)
14	Flyover	Nil	1 No.	Design Ch. 46.670
15	Toll Plaza	Nil	1 No.	Design Ch. 41.833

17.1.4 Economic Viability

S. No.	Scenario	Condition	EIRR
1	5% Growth Scenario	Base Costs and Base Benefits	13.8%

The economic analysis carried out for 5% Growth Scenario results with **13.8% EIRR** as against minimum 12% (viability acceptance) for a period of 30 years & 12% discount rate.

17.1.5 Financial Viability

Toll Plaza Locations & Tolling Length

The project road starts from the sections Kalavad to Jamnagar viz. Ch. 0.000 to Ch. 47.572. The tolling length as per the toll notifications consists of length of highway, structures having length more than 60 m & bypass costing Rs 10 Cr. or more. As per the proposed project features the details are given below:

Table 17.2: Proposed Toll Plaza Locations and Effective Tolling Lengths

Toll Plaza Location Existing km	Length of Road (without structure) (km)	Length of Bypass (cost >10cr.) (km)	Length of Structures (>60 m) (km)	Total Tolling Length (km)
km 10+000	38.429	9.075	0.678	47.572

The toll charges have been calculated as per National Highways Fee (Determination of Rates and Collection) Rules, 2008, Amendment 2010, Amendment 2011, Amendment 2013 & Amendment 2014. The estimated toll charges in year 2028-29 for both the tolling sections are as shown below:

The Tollable traffic for the base year 2024-25 at proposed toll plaza locations at km 10+000 is 5014 Nos.

The total landed cost for the project at the end of the construction period has been estimated by adding the (capitalizing) 1.25 times of the Basic civil Cost. The total project cost at the time of commissioning is thus estimated and is given in **Table 17.3**.

Table 17.3: Project Cost Summary of Concessionaire Cost (Rs. Crores)

S. No.	Concessionaire Cost	Cost (in Crores)
1	Total Civil Construction cost for 47.572 kms (design length)(A)	724.12
2	Other Costs such as IC & Pre-Operative expenses, Financing Cost, Interest during Construction, etc @ 1.25 times of Total Civil Cost	25% of (A) = 181.03
TOTAL PROJECT COST		905.15
TOTAL PROJECT COST Rs (Cr.) / Km.		19.03

Table 17.4: Sensitivity for the FIRR

S. No.	Scenario	Grant	Project IRR (%)	Equity IRR (%)
1	5% Growth Scenario	40%	7.60 %	4.54 %

The financial analysis of the project road has been carried out for a period of 22 years for 5% growth scenario. Since the base year tollable traffic is 5014 nos. at km 10+000.

17.2 CONCLUSION

The viability of the project has been examined for grant allocation of 40%. For the given set of conditions, the Equity IRR comes to be 4.54% as against 15% (viability), whereas the DSCR comes to be 0.71, as against minimum 1.0. Therefore, the project is found to be financially Non-viable on BOT (Toll) basis and recommended on EPC/HAM mode.

